

An E x a c t
Survey of the TIDE.

Explicating its

PRODUCTION } VARIETY
AND } AND
PROPAGATION, } ANOMALY,

In all Parts of the WORLD;

Especially near the

Coasts of GREAT BRITAIN
and IRELAND.

With a Preliminary TREATISE concerning
the Origine of SPRINGS, Generation of
RAIN, and Production of WIND.

With Fifteen Curious MAPS.

The Second Edition.

To which is added,

A Clear and Succinct DESCRIPTION of an
ENGINE, which fetcheth Water out of the
Deep, and raiseth it to the Height design'd,
Progressively, by the same Motion.

By E. BARLOW, Gent.

L O N D O N :

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St. Dunstan's Church in Fleet-Street. M D C C X X I I .

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PREFACE.

THE *Laws* of Motion, establish'd by Divine Wisdom in the Nature of Things, are, without doubt, uniformly and universally observ'd throughout every part of the Creation; and consequently, these *four* great Wheels of *Fluid* Nature, which I have undertaken to consider, viz. *Springs, Rain, Wind, and Tide*; must have their constant Revolutions determin'd by the same Laws, and be adjusted and carried on, exactly according to *Statistical* Principles.

But it is equally certain, that *No Man can find out the Work that God maketh, from the beginning to the end* †; nor trace the Order of remote Causes, which lie involv'd in endless Combinations, to their first Origin, in the immense Regions of *Air and Water*: wherefore, being to treat of these *Effects*, which are so well known to us, and lie daily expos'd to our Senses; I shall not need to amuse my Reader with *Hypothetical* Conjectures: grounding my Discourse all the way upon the *Things* themselves, or such acknowledg'd *Properties* of 'em, as are sufficiently ascertain'd by repeated Experiment and Observation.

As *first*, It being allow'd, that the Air gravitates (as appears by the *Baroscope*) as well as Water; and Experience assuring us, that *Springs, Rain, Wind, and the Sea*, tend always directly *downwards*, unless some exterior Impediment give 'em a Deflection: Hence I may conclude, that their common Tendency that way, by their own *Gravity*, must be the principal *interiour* Cause of their Generation, or Production; and that the Three former may be traced up to their first Origin,

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gin, by following the Tract of their constant Motion (*downwards*) revers'd; with the same Certainty, that *Rivers* are traced upwards to their respective *Fountains*, which first produc'd 'em: And whereas the *Tide* consists of an Inequality of the Sea's Surface; however it be rais'd above its natural Level, it must be depress'd again as much, by the Ponderation of its own Weight, to compleat its Tidal Motion.

But, because all direct Motion must terminate at last; and the Circulation of these voluble Fluids is perpetual; some exteriour Agent must revolve 'em again upwards, contrary to their natural Propension: And since we find by Experience, that Light and Heat raise Water, in *Mists*, up to the Clouds; and by rarifying our grosser Air, swell it higher into the Sky: Hence it may reasonably be concluded, that the Rays of the Sun, by hoisting 'em Both aloft, and letting 'em fall down again; produce *Springs*, *Rain*, and *Wind*, alternately.

These *Three*, whose Appearances are much fewer and less perplex'd, I have examin'd, after a brief manner, in my first Treatise: as a preliminary to my second of the *Tide*; They all, after some sort, affecting the *Sea*; But especially the *Winds*, which immediately stir up its Surges: and more particularly those Winds which *Trade* upon the Ocean; some periodically, to opposite Points at several Seasons; whilst others drive its Surface continually Westward: Whose Origin and Course I have describ'd, in the Close of my first Treatise; according to the *Historical Observations* of that most learned and accurate Meteorologist, Dr. Edmund Halley, the *Savilian* Professor at Oxford.

Next, concerning the Exteriour Agent, which stirreth up the *Sea*, and causeth the *Tide*: In regard the Diurnal Course of the *Moon* comes up so close, at every six Lunar Hour's distance, with the Terms of its *Floods* and *Ebbs*, as to argue as absolute a Dependence thereon,

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thereon, as any Effect whatsoever can have on its proper Cause; and this so remarkably, That *such a Moon makes such a Tide*, is the *Navigator's* common Expression; It is scarce to be doubted, but that Her Influence is chiefly concern'd in the Tidal Affair.

But whether Her proper Action be to *raise* the Sea's Surface *above*, or *depress* it *below* its natural Level, seems not so easy to determine; since its Motion, alternately *up* and *down*, may be alike occasion'd by Either.

The *Antients* generally attributed to the Moon a Power of *raising* or *swelling* the Surface of the Ocean, after the manner of Boiling Water: whence it was called the *Astus*, or Ebullition of the Sea; which they held was at *once* excited in the Parts directly under her *Meridian*, and those, *diametrically* opposite to 'em: The former by her *direct*, this by her *reflex'd* Rays. In this Opinion we find *Aristotle*, with all the *Peripatetic School*; *Strabo*, *Pomponius Mela*, *Pliny*, &c. This last Author pleasantly calls the Moon, (*) *Sydus avidum, trahensque secum haustu Maria*, &c. And *Aristotle's* Word, to express these Ebullitions, is ἀμπώτεις; which he seems to explicate by κυμάτων ἄρσεις; saying, they do (†) Συμπειοῦσθαι αἰεὶ τῇ Γεωλίῳ.

When the *Copernican* Systeme was reviv'd, many of its Favourers endeavour'd to account for the Course of the Tide from the Motion of the Earth; as, *Galilæus*, Lord *Verulam*, Mr. *Hobbes*, and others: But not succeeding herein; *Des Chartes* brought in the *Moon's* Pressure to its Assistance: (||) making the *Earth's* Rotation to stir up the ambient Air into Motion, and the *Moon's* Interposition, between the Inside of her Orb and the Outside of our Ocean, to compress it into a *Wind* within our Hemisphere; which *Wind*, as he (mistakingly) supposes, proceeding from the Rotation of the Earth to the *Eastward* (the above-named Dr. *Halley* having demonstrated the contrary;) must carry with

(*) *Hist. Nat. l. 2. c. 97.* (†) *Arist. de Mundo, c. 4.* (||) *Princ. Phil. P. 4. § 49.*

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it that Portion of Air, which is incumbent on the *Eastermost* part of the Earth, forward to the most *Westerly* Points thereof (far *swifter* than a *Bullet* out of the Mouth of a *Cannon*) in *twelve hours* space: and the Tumour of Water, which it affects, must likewise accompany it through the *same* Space in the *same* Time. Which is inconsistent with all Observation; and must render the *Art of Navigation* altogether impracticable.

The Truth is, not only *Des Chartes*, but most other Authors who have handled this Subject of the *Tide*, have fall'n under the same grand Mistakes: which are,

1. That they imagine its *proper* and *primogenial* Tendency to be from *East* to *West*.

2. That it makes High-water in *all* Places, *where* and *when* the Moon is on the Meridian.

The quite *contrary* to both which, is found true by the best *Observation*; as I have taken occasion more amply to shew throughout my *Second Treatise*.

Wherein the *Reader* (I hope to his Satisfaction) will find how I have endeavour'd to lay such *Causes* of the *Tide*, as are no ways inconsistent with the *Effects* themselves, or those *Phænomena*, of which Experience and Observation has assur'd us: How, after I have trac'd its Course throughout the *Ocean* in general, I confine my Enquiries to the *Atlantic Stem*; and soon after within the Compass of the *European Seas*; whence I withdraw 'em to the *British Coasts*; and after all (for clearer Inspection's sake) describe the Tides within our *English Channels*: and have had Recourse, all the while, to *Authors* of the best Repute, and our approved *Tide-Tables*, for Matter of Fact.

This *Essay* I have the more willingly submitted to Publick View; that *Time* and *Opportunity* might, at leisure, adjust *mistaken* Circumstances; and that, by the Assistance of fresh *Observation*, and Industry of *Art*, the whole *Theory* might, at length, be improv'd into a common Stock of Useful Knowledge.

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O R,

The Ebbing and Flowing of the SEA.

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First T R E A T I S E.

CONCERNING

The Origin of Springs, Generation
of Rain, and the Production of
Wind.

C H A P. I.

Of the Origin, and Course of SPRINGS.

S E C T. I.

*Of the Common Source of Springs, in general;
and, How they are diversify'd, by their different
Descents thro' the Veins of the Earth.*



O disclose the Source, and Ori-
gin of *Springs* in general, by
considering the Constitution of
the *Matter* whereof they con-
sist, and observing the common
Tract of their *Motion*; seeing
they are all compos'd of Elementary Matter,
(which is abundantly heavier than Air) they

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must

Of the Origin, and

must still tend downwards ; and being also of a thin and fluid Constitution, must needs insinuate themselves with Ease, into the Veins and Cavities of the Earth, how crooked and perplex'd soever ; so that to return upwards, or run Transversely, must needs be contrary, or beside their Natural Propension ; and consequently not to be admitted, but in Case of some Obstacle or Impediment, which may Exteriously divert their Course, against their Interior Inclination.

And for Distinction's sake : 1. They are divided into *Day-Springs* ; which, either lying near the Surface of the Earth, or finding free Passages thither, break forth into the open Air, on their own Accord ; while those of the *Deep* are sunk down so low, as to require Buckets and Chains to fetch 'em up again. Next, they are call'd *Top* or *Bottom-Springs* ; inasmuch as they appear either above the Rock, which severs the Soil from the Mine, or underneath it : Moreover, *Top-Springs* differ from *Day-Springs*, in that they stagnate between the Superficies of the Earth and the Surface of the Rock, till they be open'd by the Miner ; and *Bottom-Springs*, that can be let off by Soughs and Trenches, are distinguish'd from those of the *Deep* ; which, to be drain'd by such Means, is either altogether impracticable, or absolutely impossible.

Next, it is farther observable, that all those Sorts of Springs proceed originally from the same Source ; to wit, *Rain* and *Dews*, distill'd from the Clouds : And they are diversify'd by their Transfusion thro' the Veins of the Earth, whereon they are scatter'd. For, in Case they

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they be imbibed by a loose and porous Soil, they presently break forth again into *Day-Springs*; or, if their Course be obstructed by some slimy or soapy Matter, they are still exerted against the Miner's Pick, in *Top-Springs*; or else, if let down by the Chinks of the Rock, they meet him again below it, in *Bottom-Springs*; or finally, if they lie too far distant from any River, of a Lower Situation, to be Taken off practically; or else Lower than the Sea, to make that impossible; they are properly Springs of the *Deep*, and no farther to be Accounted for; the Floor they last fall upon, being Seamless, and scarce penetrable; and whether Solid, or Hollow, Uncertain: The rest will be made manifest, by respective Observations, in the following Sections.

S E C T. II.

Of the Origin, and Growth of Day-Springs.

IN the Search after the Original Source of those Rills, and Currents of Water, which, issuing out of the Earth, are commonly call'd *Day-Springs*, or *Fountains*; the First Consideration that occurs, is, that their Natural Course, as consisting in Motion merely Local, & caused by the Propension of their own Weight, still drawing them Downward towards the Center of the Earth, their Course must always be upon a constant Descent, from a Higher Situation to a Lower; and so must

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proceed

proceed Originally from *Rain*, distill'd from the Clouds: And if it happen, that at their Emergency out of the Earth, their Spring riseth Upwards; 'tis caused by the Curvity of their Passage, that (*Syphon*-like) pointeth that Way; while the Preponderation of the Water, contain'd in its other Arm, descending from a greater Height, forceth it to Rise, contrary to its Natural Inclination.

Hence it comes to pass, that Springs seldom break forth in Plains, or Champion-Ground, for Want of an Ascent to raise them, and a Descent to let 'em off again; but the Rain that chanceth to fall there, either stagnates into *Pools*, and *Lakes*; or if it be imbibed by the spongy Soil, it sinks into Beds of Sand, or Gravel, to be convey'd by Subterraneous Passages, to some lower Situation of Valleys and *Rivers*, that discharge it last into the Ocean; or if it be employ'd to furnish *Pits*, or *Ditches*, dug deeper into the Earth, they never rise Higher than their first Source; or the Superficies of those Plains, that imbib'd the Rain which first produc'd 'em.

But, in Case those Springs get the Advantage of a Higher Ground, to Rill themselves down into a Lower, by descending thro' the pervious Sand, or Gravel, till they break forth at last into the open Air; they run themselves off in a joint Proportion, to the Extent of Ground whereon the Rain fell, and the Capacity of the Orifice that vents 'em; so that if the Former be but small, and the Latter too large; such weak and unconstant Springs run themselves out, almost as soon as the Showers are fall'n, that replenish'd 'em.

Or,

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Or, if Springs of a stronger Stream, and a longer Continuance, chance to rise upon Plains; the Eminence that feeds 'em, cannot be small, nor afar off, and seldom above a League; and the Quarry of Stone, which conveys 'em thro' its Chinks, must crop out of the Ground in the same Place; or the Bed of Clay, or Marl, that had suppress'd 'em all along, must break off, or be discontinued, to let 'em off into the open Air; at a Rate proportionate to the Veins of the Earth, thro' which they are to pass, and the Stock of Water that maintains them.

Afterwards, if we climb those Mountainous Heights, which most abound with Springs, we shall find Cause enough for 'em; and a competent Extent of Surface, to receive a proportionable Quantity of Rain, for their Supply; and Clifts of Rocks every where wide open, to receive and convey it into the Caverns of the Earth, as Reservatories to detain it; till the Chinks underneath, can let it off again at leisure, for a constant Supply to water the Valleys below, perhaps for the whole Summer's Season.

And, at last to mount the Tops of those Hills, whence these Subterraneous Rivulets derive their Origin; they always occur to us upon a constant Descent, and are divided into Branches, Upwards; still becoming gradually smaller, till their utmost Extremities terminate after all, at the Surface of that Height, from whence they drew their first Source; and were Originally distill'd, by innumerable Drops of Rain, from the Heavens themselves; as being

Of the Origin, and

the first Source and Origin of all the *Day-Springs*, without Exception.

Hence it is remarkable, *First*, That Springs are never found upon the Ridges of any Hills, for Want of Ground of a Higher Situation, to distill Currents of Water to supply 'em; nor upon those Plains that are exactly Level, for Want of a Lower Descent, to carry off the Rain that falls upon 'em: *Next*, That the Springs, which break forth nearest the Tops of those Hills, are soonest supply'd with Rain, and as quickly evacuated; but upon a Lower Descent, they become slower in receiving their Recruit, and longer in spending it; whereas Those, that rise at the Foot of the Hill, run perpetually; and suffer only a Decrease in Summer, of what they Increased in Winter, which may perhaps arrive at length, to an Equality: just as Water, poured (like Rain from the Sky with Intermissions) into a Tub bored full of Holes, and filled with Sand, is soonest evacuated by Those, that are nearest the Top; which run off almost as soon, as the Infusion ceaseth; and the Lower they stand, the slower they are replenish'd, and hold out longest; whereas Those of the lower Tier, flow perpetually; and perhaps at last, without any Variation at all.

For, so it happens in the strongest Springs; which force their Rise, out of the Bottoms of the Highest Hills; especially when the Orifice of their Eruption, holds not a full Proportion, to the Source which maintains 'em; as doubtless it does not at *Holy-Well*, in *Flintshire*, one of the most plentiful Springs in the World;

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World; which being surrounded, almost on all Sides, with very High Hills, one heap'd upon the Back of another, keeps up its Stream to the Highest Pitch, in the greatest Drought in Summer : Whereas another Spring at *Bardsea*, below the *Lancashire* Fells, in Winter, drives almost an equal Stream with it ; yet decays considerably at the contrary Season, for Want of a competent Supply, to keep it up to an Equality. A convincing Argument, that the Sea, tho' adjacent to 'em Both, is neither the Common Source of these Two Fountains, nor holds a strict Communication with 'em ; to keep the Former, exactly to its greatest Height ; and yet let the Latter fall with so considerable an Abatement, that near a third Part of its Stream is lost.

And, to compare those Springs with those Rivers, that take their first Rise from the Tops of the same Mountains ; as they are fed by the same Showers of Rain, so their Growth and Increase continue much alike ; but the Manner of their Course, and its Effects, become as different : For whereas Rivers receive their Recruits in open Channels, expos'd to the Air ; Springs, on the contrary, have Theirs first imbibed by the Earth, to be convey'd away thro' close Conduits, under Ground : Those still float upon the Surface of their Paths, and can only vary their Course, To and Fro ; but These, that sink into the Deep, are diverted every way, into an endless Maze of Perplexity : Those fall with Precipitation, down the Valleys into the Plains, which they overflow ; while These derive their Rills out of all Sorts of Metals, and Minerals, through

which they are to pass into their Reservoirs, for the Summer's Season : Those, flowing all the while with open Banks and a free Passage, discharge their Floods upon every Shower ; while These, be the Feeder never so great, their Passage is so perplex'd , and streightned on all Sides, as to pass 'em off so regularly, that sometimes they admit of no sensible Variation.

Thus much may suffice, for a full Display of the Cause of those Currents, that are call'd *Day-Springs*, and break forth of the Earth into the open Air ; which, being Liquid, and following the Course of Nature, must easily insinuate themselves into the Crevices, and Caverns of the Earth ; and withal, being of a heavier Constitution than Air, must every where expel it ; and so, according to Reason, must Originally proceed from Showers of Rain falling upon a Higher Ground, which imbibes 'em ; and are actually found by Experience, upon a constant Descent till their Eruption. Let us see what is to be said of the Springs of other Sorts, which lye conceal'd in the Bowels of the Earth, till the Miner takes the Pains to discover 'em.

SECT.

Course of SPRINGS.

S E C T. III.

Concerning the first Source, and Production of Top-Springs.

THUS far Reason and Experience being agreed about the Origin and Growth of *Day-Springs*, which arise out of the Earth into the open Air, on their own Accord; and chiefly serve for the Earth's Refreshment, amidst the Summer's Heats; and the supplying of Rivers with Water, in Droughty Seasons; we must descend to Those, which are discover'd under Ground by the Miner's Industry; and belong after a special Manner, to his Inspection.

Now as to those Rills, which are commonly call'd *Top-Springs*, tho' they jointly partake of the same Origin with those of the *Day*, and are immediately supply'd by Showers of Rain; yet they never overflow on their own Accord, either for Want of Fall into some Lower Situation; or else because they are not furnish'd with a competent Force of Water to make an Eruption: but still remain shut up in Beds of Sand or Gravel, lying between the Soil which covers 'em, and the Rock which sustains 'em; and at a competent Distance from the Surface of the Earth, to send up plentifully Steams and Vapours, to cherish and refresh the Roots and Stems of Vegetables of all Sorts.

Concerning the Production of Springs of this Sort, inasmuch as they depend on the Miner's

Miner's Pick and Spade to discover, and set 'em on foot; about the Beginning of *September*, after a Summer's Drought, when he first breaks Ground, he finds the Soil dry for a Spading deep; and so it continues, till the first steeping Shower sinks into it, perhaps an Inch, before the Next falls; which, finding the Earth somewhat dampish, pierceth it considerably deeper; and the Third, after it is much better dispos'd to receive it, penetrates deeper still; and so does the Fourth, Fifth, &c. progressively; making the Way easier, for those which follow; that showry Moisture, the lower it sinks, growing denser; yet 'tis so imbibed and incorporated with the Soil, that they grow into so clammy a Sort of Mud, that neither the One can properly be called Earth, nor the Other, Water; as long as that Month lasteth.

In *October*, that Moisture being condens'd, sinks by Degrees thro' this clammy Matter, into the looser Sand, or Gravel, whose Pores are opener to receive it, and stony Particles cannot be pierc'd; whence it becomes a separate Substance; and is actually strain'd out of the Mud, by Percolation, into Water of a Fluid Constitution; yet still remains divided into so Minute Parts, by the Smallness of its Receptacles, that it continues fix'd (as the Liquor does in a Honey-comb,) till it be squeez'd out by the Miner's Stroaks, which set it at Liberty: And having once got Vent, such crizzling Rills creep thither-wards from all Sides, especially from the Rising Ground; whence their Fall is greatest, and their Stock is most increased; and such Springs as these are

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are dried up in a few Days; but being replenish'd by every Shower of Rain, serve to supply Ponds and Lakes of a greater Capacity.

But, sinking deeper into Beds of Sand and Gravel intermix'd, and opening vacant Spaces of a larger Size, to hold more Water; the Top-Springs issue out of 'em in greater Plenty; and increase, upon their Confluence with one another, at every turn, into brisk Currents; till at last, insinuating themselves into the Chinks and Crevices of the Bastard-Rock underneath, they find Caverns and Reservoirs for a longer Season; but still with Intermissions in Summer and Winter, if they continue fair for any considerable Space of Time, and sometimes without 'em: They begin to rise in October, and hold out till a long Frost dries 'em up; and the first Thaw sets 'em on running again, and they last (with some Intermissions) perhaps till June; and so continue the Year round, to supply Pumps and Draw-Well, which are their Reservoirs; until Droughts extraordinary quite exhaust 'em.

But if the Soil, impregnated with Rain-Water, lye upon Clay, or Marl, or any other impervious Matter; and again, these chance (as commonly happens) to rest upon Beds of Sand, or Gravel, for any considerable Space of Ground; the Water, which descending from the Crop-side is lodg'd therein, stagnates, till the Miner's Spade, or Augur, raiseth it; and then it becomes a Spring of a stronger Current, and of a longer Continuance, and is mostly perpetual; and if the Pit, or Pipe, whereby it is rais'd, proves stanch, it ascends by Counter-Libration, as high

high as it had descended before ; and keeps to near the same Stream, both in Summer and Winter, tho' never to an Equality.

And in Case the said Springs receive part of their Recruits from some adjacent *Lake*, or *River* ; 'tis always, as a late *French* Author well observes, from a Higher Situation : so that still they are duly replenish'd with Rain, either at the first or second hand ; forasmuch as Lakes and Rivers continually evacuate themselves, either by Flux of Stream, or Emission of Vapours ; and must be replenish'd, either immediately by Rain from Heaven, or by Springs out of the Earth ; as is manifest : And the same Author farther remarks, that they re-ascend to the Height of their Fountains ; as he says they do in *Paris*, near the *Seine* ; where they Rise and Fall with that River ; and as they do near *Warrington* in *Lancashire*, within a Mile or Two's Distance from the River *Marshey*, where a Bed of Marl lies upon Sand ; and no doubt but the like is done in all other Places, on the same Occasion.

Thus all *Top-Springs* consist of a Stock of Rain-Water, laid up mostly in Beds of Sand, or Gravel, between the *Day* and the *Deep* ; a commodious Depository to receive it readily, upon every Recruit from Heaven ; and to part with it as freely, when the *Bottom-Springs* require it : but they are only Springs of the Miner's making ; or otherwise, they hold fast what they can get ; having room sufficient for a Reservatory, of the Vernal and Autumnal Rains, to supply the future Expende of the Summer's and Winter's Seasons. Let us try, and

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and see how their Correlative Bottom-Springs
can draw 'em off upon Occasion.

S E C T. IV.

*Whence Bottom-Springs proceed; and how they are
propagated in the Veins of the Earth.*

TO descend from those Rills, which stagnate in Sand or Gravel, between the Soil and the Rock, till the Miner's Pick or Spade breaks open their Inclosure, to the Bottom-Springs, which are immediately derived from them; it is to be Observ'd, That the said Sand and Water lodg'd together, rest upon a Plane compos'd of sundry Sorts of Metals; as Bast, Iron-stone, White-Earth, &c. cropping out to support 'em; which mostly are of so compact a Substance, or lye so close bedded together, as scarce to let down any Water betwixt 'em; yet Others, of a more porous Sort, are interpos'd at certain Distances; or else are so disjoin'd from their Fellows, as to transmit a Quantity sufficient to furnish Springs of sundry Sizes; according to the different Constitutions of the said Metals, or the Capacities of the Clifts, which contain 'em.

Again, the said Metals being not of Luminous and Globular Figures, to scatter their Water every way alike, as Light passeth thro' Diaphanous Bodies; nor of a Cubical cut, to distract its Streams several ways at once; nor do they lye heap'd confusedly together,

gether; to leave their Common Course undetermin'd; but are flatted into *Plains* with a sloping Declivity, to let their inclosed Springs descend leisurely, and carry 'em off to a new Ground: And sometimes the whole Mine lies so true, and the Series of its Beds are framed after so equal and regular a Manner, that the Miner, being inform'd what *Dip* it hath, and which way it lies, may easily compute at what Depth his Springing Vein will be open'd, at any Distance within his Compass; perhaps to a Foot at a Furlong, or to a Yard at a Mile.

Hence it is, that at what Depth, or Distance soever within his Compass, he opens his Spring with Pick, or Auger; the Orifice which he makes, presently draws all those that lye above it, and are fed by the same Vein Thither; insomuch that Fountains, which are fed by it, are often drain'd at a Mile's Distance; while Others are spared, which rise but a few Yards off, because they derive their Streams from other Sources.

And when his Pit is to be sunk in a Bog where *Top-Springs* most abound; to keep it dry, his first Endeavour is to stop (if possible) the Mouth of the Vein, which affects his Mine; or to take it off with an open Trench, if it be practicable, above Ground; or else to divert its Stream by a close one, underneath (his Pit being already ramm'd about with temper'd Clay) before its Irruption; and by this Means, the Pains and Expence of tugging his Water out of the Deep with Horses and Engines, is saved; while it runs it self off to the Day, upon its own Level.

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And as for the final Retreat of these *Bottom-Springs*, under the Bowels of the Earth; if it chance that those of the Deepest Sort can find a Vent into a Lower Situation, or want a Passage to convey 'em thither, they presently migrate; and upon every fresh Supply of Rain from above, their Course recoils by *Libration* backward, towards their first Source: And in case the Veins of Metal, which contains 'em, prove stanch and strong enough to sustain their Weight, they fill, by degrees, all the Cavities, whereby they descended, up to the top with Dead Water; and the supervening showers of Rain no longer penetrate their Orifices (being brim-full already), but diffuse themselves in the said Sand, or Gravel, as before described.

But, in Regard the said Cavities always lie in a sloping declining Posture, between Two Beds of Stone, or some other Metal, the One under the Other; and the Higher often becomes the *Roof*, and the Lower the *Floor* of the Mine, which is sought for: Hence, if the Miner chanceth to pare the Rock over-head too thin, or to sink his *Sump-hole* deeper than ordinary; the aforesaid Dead-Water breaks out of its Enclosure, and rusheth in upon him with so great Violence, as to endanger his escape; and drowns his Work in a Deluge, but seldom beyond Recovery; unless that space of Ground, which feeds those Veins, and fills their Cavities with their Distillations, proves too great for his Pumps and Buckets to master; for otherwise, their Stock of Water being once drawn out, his Work is laid dry, and he easily keeps it so; having only its Feeder

Feeder to draw off as it comes, which cannot hurt him.

For an Instance of the former Sort; *Scarsbrick* in *Lancashire*, the Miner, in his Search after Coal, or some other Mineral, when he had bored Twelve or Fourteen Fathom deep, thro' a close and compact Sort of Metal, and dry all the while; chancing to meet with a more Porous and Open Vein of Earth underneath, a violent Stream of Water follow'd his Augur to the Top of the Ground and rose up a Tube at least Ten Foot higher by the Force of its Ascent, to shew the Emission of its Origin; and has maintain'd the Stream, without any sensible Diminution ever since; in Proportion to the great Compass of Land whereon the Rain fell, which supply'd it: Whereas another Spring of the latter Sort was rais'd in *Ellel* near *Lancaster*, on the like Occasion; which burst out at first with the like Force, but soon ran it self into a feeble Rill, and at last ceas'd; plainly shewing, that it deriv'd its Source from Higher Ground, than where it issued out, as well as the former; but wanted an equal Extent of Land to feed it; or a Metal of as close and staunch a Texture, to preserve it.

Hence it is manifest, that tho' the Place aforesaid consists of Metals, how compact and close join'd together soever; yet lying in distinct Beds, each beside its Fellow; and all in the same sloping Posture, with their Upper Edges cropping out to Sand or Gravel, impregnated with Rain-Water; they must needs transmit a competent Portion of it into Bottom-Springs, which constantly descend from the

the Rising Side of the Mine, as deriving their Source from the *Top-Springs*; and penetrate the Deep by those Degrees, and after the same Manner, as I have already described; (according to the daily Experience and long Observation made by a Person of Ingenuity and Credit,) without the Additional Supply of *Air condens'd into Water*, or of *Water rarified into Vapours*, in the Caverns of the Earth; much less of Rills, convey'd through its Cavities out of the *Sea* into *Bottom-Springs*; that are found Higher mounted than it, sometimes an Hundred Fathoms.

S E C T. V.

Concerning Springs of the Deep; Whence they proceed, and How they are distinguish'd from the Rest.

TO descend, at last, to the Springs of the Deep, and consider 'em precisely, as contradistinct from Those of the Day; it sufficeth that they never appear to the Light of the Sun, on their own Accord; but as such, they are co-incident with *Top-Springs*, which lie conceal'd, till the Miner discover 'em by Force: And, inasmuch as They penetrate the Depth of all Mines and Quarries; *Bottom-Springs* dive as deep into the Bowels of the Earth as They; and so can differ from 'em only in Name, but not in Nature; yet These may be taken apart, as they are absolutely

undrainable by Soughs or Trenches, to a Lower Situation; and, consequently, must lie as low as the Surface of the Ocean it self, to find no other Reception.

Now, whether their Affinity to the Sea may cause a Participation with it; or their Submission to its Surface create a Dependence of such Springs on its Influence upon 'em: It cannot be Deny'd that Salt-Water may sink into the Chinks of Rocks, and insinuate it self into their Crevices, as well as *Fresh* Rivers; but never to Excess, as is found by Experience; when the Miner drives his Coal-Works under *Tine* near *Newcastle*, for whole Miles together; and does the like under the Sea it self, on the Skirts of *Wales*, without any Remarkable Inconvenience on that Account; but rather, on the contrary, finds the *Roof* of his Trenches stancher, and the Chinks of the Rock stopp'd closer with Mud and other slimy Matter, than where they lie open to Sand and Gravel, in other Places.

'Tis confess'd, that *Draw-Wells* in Sea-Port Towns, and *Cisterns* dug below the Flood-Marks on the Sea-Shore, sometimes contract a Brackishness, either from an Intermixture of Salt-Water, or from the *Rock* that conveys it: But if the Springs lie above those Marks, or at more than half a League's Distance off, (as those at the *Wiches* do,) they are impregnated by Salt-Rocks, that are steep'd in Rain from Heaven, which is converted into that Briny Liquor; or else they never rise Higher than the Brink of the Sea; though they be never so near it, or spring from Caverns never so much below it; as appears by the afore said

Spring

Spring at *Searsbrick*, that drains its Stream from some Fathoms below the Sea; and Thence at *Bandsa*, which dischargeth itself immediately into It, at the Rate of an Hundred Tuns an Hour; yet Neither of 'em, in the least, contracts any *Seasish* Qualification; or resents its *Ebbs* and *Floods* one Jot, tho' they Border upon it.

Whereas, on the contrary, Springs of all Sorts express their strict Dependence on the Supply of *Rain*; by never failing to Rise or Fall, consequently to every Wet or dry Season of the Year; especially of *Summer* and *Winter*: Those that lie deeper, growing successively slower in receiving their Recruits, and holding out longer in spending them: Some begin to Rise in *September*; Others stir not until *October* be over; and attain not to their full Height till *February*: Or, if they begin their Increase later, they continue Rising till *March* or *April*; and Those of the last Sort sometimes, reach not their utmost pitch (as *Holy-Well* in *Flintshire*) till *Midsummer*; *Top-Springs* being sometime *Temporary*, and suffering *Intermissions*; but *Bottom-Springs* *Perpetual*: And the Deepest the most constant and Equal.

Thus I have travers'd the whole Course of Springs, from the *Top* to the *Bottom*; and found their subterraneous Rills at all Heights, still descending by an undiscontinued Tract, well known and closely follow'd by every *Collier*; without making any false Step, according to his best Observation: Nor have I laid any other Principles to ground my Discourse, than

what he still supposeth, throughout his Work, to be *Self-Evident* and *Undeniable*: viz. That *Water* (which is the Matter whereof all Springs consist) is *Heavy* by Nature, to press their Tendency constantly Downwards; and withal of a *Liquid* and *Fluid* Constitution, to insinuate them into subterraneous Passages of all Sorts and Sizes.

S E C T. VI.

Objections against the Precedent Account of the Origin of Springs, solv'd.

SO manifestly (as I have shewn,) do all *Kinds* of Springs, found in the World, proceed from the Diffusion of Rain upon the Surface of the Earth; (as being diversified into several Sorts, by as different a Reception into its Bowels, and as various an Effusion out again into the Open Air;) that every rude *Collier* plainly sees, and fully understands How it is Effected: Yet Those, who wou'd have their Thoughts appear better cultivated by Reflection and Study, seem to be of a contrary Persuasion: Some raising *Objections* against Sense and Experience; and others advancing different *Opinions*, with as little regard either to the One, or the Other.

First, Whereas it is commonly Reported, that Rain never sinks deeper than *Ten Foot* into the Earth; and yet plentiful Springs sometimes

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sometimes occur in the *Bottoms* of the deepest Mines ; 'tis a vulgar Error, As to the Former part of this Assertion, and flatly contradicts the Miner's Experience ; who daily Observes, that all the Springs of the *Deep* constantly descend from the *Rising* Side of those Mines, which they affect ; and derive their Source from the *Day*, as being Originally fed by Showers from Heaven ; which, falling upon a spongy Soil, presently sink into Beds of Sand or Gravel ; and thence descend into the Clifts of the Quarries underneath ; and are transfused into the Mines below, to a Depth indefinite.

Secondly, To affirm that the strongest Springs rise out of the *Tops* of the Highest Hills, is as bold and unprov'd a Paradox as the Former ; or, that they rise so near the *Tops* of those Hills, as not to afford a competent Space of Ground to gather *Rain* enough for their Supply, must needs oppose the Nature of Water ; which never riseth Higher than it is forced ; as well as it contradicts Reason, which tells us plainly, that Springs, which are the *Effect*, cannot exceed the Height of the Place where the *Rain* falls, that *causeth* 'em.

And, to pretend the Origin of *Nile* for an Instance of so strong a Spring, and so High mounted, is as disagreeable to the Account of our Modern Geographers ; who derive it from the Lake *Zembre*, which exceeds three Hundred Leagues in Compass, and is the great Drain of the Upper *Ethiopia*: Or, in case any of those Rivulers, which fall into that *Lake*, shou'd flow from any such Spring ; Why it shou'd rather be the Head of *Nile* than of *Zair*,

the third River in *Africk*, which also proceeds from the same *Lake*, is hard to conjecture : Unless to advance This as one Paradox, amongst the Rest which have been feign'd of the Origin of that River ; since no such Springs are to be found in our Quarter of the World ; where *Rivers, Lakes and Seas* most abound, to furnish 'em : To produce, I say, and insist upon such *Miracles* in Nature, and *Mysteries* to Reason afar off, contrary to the Experience of all *Europe*, must needs lessen the Credit of the Reporter.

Thirdly, It is Urg'd, that the *Tops* of those Hills, where such Springs are found, are often Ridg'd with Rocks, which hang over the Sea, and are separated Each from other ; besides, they are said to be *Bare and Impenetrable* by Rain. To which may be Reply'd, that if those Rocks be so pervious, as to let out Springs to spend themselves ; they must needs be as penetrable by Rain, to supply 'em : Again, if they be Bare, their Clifts are more expos'd to the Rain, and stand wider Open to receive it : Moreover, their Conduits being made of Stone, they will serve to convey their Rills into the Sea, with less Loss of Water : Finally, Those Rocks being separated from their Fellows, their Springs must also be divided into smaller Rills, in the same Proportion.

And, for an Instance of a Spring of this Nature, we have one nearer Home, in Low Furness in *Lancashire*, which dischargeth above a Hundred Tuns of Water Hourly, out of a bare and barren Rock, close to the Sea ; yet wants not, on the other side, a sufficient Supply of the Rain, that falls upon the adjoining

Lime-

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Lime-Stone Hills, for a large Compass thereabouts ; whose Clifts gape wide Open into the Air, to receive and swallow All down, as soon as it falls ; without putting off the least Rill any other Way.

Fourthly, It is Asserted, that in several Places of *Africk* and *America* (where is seldom Rains,) are such plentiful Springs, that they presently swell into vast Rivers : Whereas there are but Three such Rivers in all *Africk* ; and Two only in that Part of *America* that wants Rain ; and no Two of 'em but drains as great an Extent of Ground as the one half of *Europe* ; so that they swell not presently to so vast a Bulk as perhaps our *Danube* does, which receives into its Stream *Sixty* Navigable Rivers, yet is not half so far Extended : Besides, there are vast Tracts of Land, in both those Quarters of the World, that lie *waste* and *desolate* for want of Springs to refresh 'em ; which plainly shews there are no such Store of 'em, as the *Objector* supposeth.

'Tis true, the *Nile*, *Zair*, and *Niger*, are Rivers of the first Magnitude, and drain the greatest Part of *Africk*, and yet are seldom replenish'd by Rain ; but the Two Former are once a Year so plentifully furnish'd, that their Winter-Supply holds out in spending it self, from Our *Midsummer* till the *May* following, that it be wholly let off from the *Zembre* : And the Last draws its Origin from the Mountainous Part of *Ethiopia* ; where there are all sorts of Weather to maintain it, as well as upon the *Andes* in *America*, for three Hundred Leagues together ; or else all *Peru* wou'd fare the worse for it : And as for those Places

where it seldom Rains, Springs must be as rare, or else the *Dews* as great to supply 'em; the Nights being constantly near *Twelve Hours* long, to let 'em fall, before they can rise so High into the Air as to become Rain; yet they are no less in Quantity, tho' not of the same Species.

When it is farther *Surmis'd*, that so small a Supply of Water as the Rain affords, wou'd scarce suffice to furnish Springs, for so continual and lasting an Expence. 'Tis *Reply'd*, that upon a just Computation, the Rivers swoll'n by the said Supply into Floods, sometimes vent more Water in *Thirty Hours* Space, than all the Springs, within that Compass, spend in a whole Year.

Again, The Showers that fall within the Space of *one Year*, wou'd, by a just Computation, suffice to stagnate all that Compass of Ground, whereon they fall, *Nineteen Inches* deep; which sufficeth to furnish a Supply for all those Rivers which rise within that Compass, during that Space of Time; with an *Overplus*, much more than to keep on foot the said subterraneous Evacuations; did not the *Vapours*, rais'd by the Sun, take off the Remainder.

Lastly, As to the *Fountain*, that in the Beginning of the World water'd *Paradise*; and the River that went out of it, which was divided into *Four* great Rivers, before our Lord had Rain'd upon the Earth: It is *Reply'd*, and may well be supposed, that God created All things (as well as *Adam* himself) in that perfect State wherein they were to continue, according to the Ordinary Course of Nature; and,

are, the Rivers, were fully replenish'd with Water, soon as they were Created; and were so to continue, till they cou'd receive a seasonable supply of Rain; as well as Now they do, from one Shower of Rain till another fall; and so also till a Second, and a Third prodigiously; not to Multiply Miracles, without necessity. And, not to omit those *Objected* imaginary *Subterraneous Rivers*, which might possibly flow from a Defluxion of subterraneous Rills; *Whither* they can continually run, and *How* they can send up Springs to the Tops of Mountains, are alike Unconceivable: And, if Divine Providence has contriv'd such a Passage, to let off the Superfluity of the *Caspian-Sea* into the *Euxine*; as well as the *Guadiana*, which passeth several Leagues under Ground, to prevent a considerable Part of *Spain* from stagnating: 'Tis plain, that they were not Ordain'd for the raising Springs to such prodigious heights, as are imagin'd; but for Other Uses.

SECT. VII.

The contrary Opinions Confuted.

OR, in case any *Additional Supply* of Rain, beyond what is Usual, were still required to keep on foot the ordinary Course of Springs; Let us see by what Means that Deficiency

Deficiency can be made up, by Those who advance that Persuasion.

The *First* which is Assign'd, and chiefly insisted on, is the Ocean it self; but with very little Hopes of Satisfaction; since the Sea is lower than the Rivers that descend into it. And again, These are lower than any Part of the Land which they drain, as being always upon a constant Descent: Whence it follows that no Spring can arrive from the Sea to any Part of the Surface of the Earth, (whence the All Spring,) without rising Upwards; contrary to the Bent of its own Inclination.

And when, to weaken this Consideration, it is surmised, that the Ocean's Surface is Protuberant, swelling Higher in the Middle, than the Tops of the highest Mountains: 'Tis Reply'd, that plain Experience finds the Surface of Water always, and every where, Level; and it is as much against Reason, that a Flat and Ponderous Body should stand in any other Posture.

Again, To Abett this Mistake, they observe that Ships entering into the Port make more haste, than they do out again; and it is no Wonder: For, coming In, they are always upon a full Speed; but going Out, they attain to that Celerity by infinite Degrees, which must take up Time, and Retard 'em till they be Acquired.

And whereas 'tis Urg'd, that Hills are discovered afar off at Sea, which appear'd not nearer hand: 'Tis Reply'd, that the hindermost Hills, which are last discover'd, are really the Highest; and so from a true Prospect appear

near afar off in their proper Place, and
 atop the Rest; tho' the Surface of the Sea
 not at all Advanced.

To correct this Mistake, They alledge, that
 Water so much *preponderates* the Fresh, that
 Depth of the Ocean, on that Account,
 raise Fresh-Water Springs above the *Pique*
Teneriff: But of what Metal those Tubes
 be made, that cou'd suffice to support
 Columns of Water to so vast a Height; espe-
 cially at so many Leagues Distance from the
 Shore, where the Ocean is so deep; and with-
 out prove so stanch, as to convey it as many
 Leagues at Land, and to the like Height,
 without spending their Streams in the inter-
 mediate Plains, and Valleys underneath; No
 Man can tell.

And, altho' Salt-Water be *heavier* than
 Fresh; yet in case those subterraneous Passa-
 ges be of too large an Aperture, to take off the
 any Constitution of the Water by *Percolation*,
 will still retain its former Weight; and so
 can never surmount the Surface of the Sea,
 from whence it came: Again, if those Passa-
 ges prove so *streight*, as to separate the Salter
 particles from the Fresh-Ones; the protrusive
 Force of the Sea's Preponderation being *Vio-*
lent, the farther it goes the more it must Abate,
 and so fall short of its first Origin; while the
 Motion of the Water's Gravitation, so con-
 tinu'd, being *Natural*, must still recover its
 proper Tendency Downwards, till at last it
 come Perpendicular.

And it is vain to have recourse to *Filtration*,
 to advance those Springs above their Origin;
 whether

whether they be pretendedly deriv'd from the *Ocean* ; or rais'd by subterraneous *Lakes* or *ivers*, generated in the Bowels of the Earth. As if it were easier to *climb* a Hill, than *walk* upon a Plain ; or more feasible to force Water *up* a *Filter* against its own Inclination than to drive it *forward* upon a *Level*, without any such Impediment.

For as to the *Filter*, thro' which the Stream is to pass to the Height design'd ; since it has no *Attractive* Vertue to raise it ; and may be made of any Porous and Pervious Matter ; and is not Actuated with any kind of Motion that is Local, to *force* it Upwards against its Inclination ; whether it consists of a Texture of *Filaments*, finely twisted into a Thread of *Filaments* ; or be compos'd of *Globular* Particles mass'd as close together as common Earth is. It can only assist to *support* that Stream, while some Exterior Agent takes the Pain to *raise* It.

And, forasmuch as neither the Water can raise it self, nor the Filter sufficeth to perform that Office ; the *Pressure* of the *Atmosphere* must enliven the Work, by its *Incumbent* upon the Fountain's Superficies, and drive the Stream up into the *Cotton* ; and after That sustain the impending Column ; and, by an ever-repeated Impulse, still keep it in Motion : But, in regard Water is a *Fluid*, as well as *Heavy* Element ; to perfect the Operation, Ambient Air must encompress the Filter *all* on *all* Sides at once, to keep the Current within the Compass of its Enclosure ; till it arrives to the utmost Pitch, that the Energy of its first Impulse cou'd raise it ; without scattering

Drop of its Liquor, or suffering any per-
ible Distillation.

Now, in Regard the *Label*, on the descend-
Part from the Center of its Gravity must
like surrounded, and compress'd by the
on all Sides, from Top to Bottom; the
posed Stream must, every where, meet with
same Difficulty to make any Eruption:
whereas, at its Ascent, the Threads of
Context serv'd for Steps to climb to its sta-
Height; Now, upon its Descent, they fit
well for Seats of Repose, to retard its Mo-
; so as to hold every proportionate Part
Equilibrions with its Opposite; and keep
whole steady, in an equal Poise; till the
ut of the Filter reach below the Surface of
of *Fountain*, to draw the Stagnation into a
ent by its Preponderation.

Thus *Filtration* is found expedient for puri-
of *Liquors*, by Percolation thro' some po-
Matter, from Vessels of a Higher Situa-
to a Lower: Nor does it import, whe-
the Capacity of the Filter be great, or
; or the Cistern, wherein it is dipt, be
larger, or more contracted Orifice; or
it be sunk deeper therein, or not; nay,
it were to the Bottom of the Sea: for
bon-like,) to whatever Height it shou'd
nce its Stream, it wou'd not part with
single Drop, till it descended as low as
Fountain whence it arose: So vain it is to
ine, that *Lakes* and *Rivers*, embowell'd in
Earth, shou'd, by this Means, fend forth
ngs on the Tops of the Highest Moun-
: When Reason and Experience makes
ain and manifest, that None can be vent-
ed

ed a Foot above its first Source; let the F
be of what Composition, Capacity, or
plication soever.

After all, the said Springs must be re
nish'd by those subterraneous Conduits, un
every Increase, at the Bottoms of the H
before their Supply can reach their To
and must rather observe the *Flooding* of
Sea, than the *Falling* of a *Shower* of Ra
Whereas, on the contrary, Those that
Highest mounted are soonest furnish'd, and
quickly run off again, after the *Shower*
fall'n; without any Regard to the Sea at
which, belike, has not been rais'd a Foot ab
its Natural Height, by all the Rain that e
fell, before the Deluge or after it, since
Creation.

To Others who pretend to Argue, fr
the *Effect* to the *Cause*, That *Intermitting* Spring
which so much resemble the *Ebbing* and *Flo*
ing of the *Tide*, must needs depend on the
cean for it; 'Tis soon Reply'd, That their
rious and uncertain Motions Conclude
Contrary; some *Ebbing* and *Flowing* ev
five or six Minutes, as One near *Settle* in
shire: Another every six Hours, as in the
cess, of *Paderburn* in *Westphalia*: A Thir
Peak, about once a Week; the *Gypas* at *Baven*
scarcely once a Year; and the *Eruption* of *P*
Hill, happens but once in an Age. An Ir
gularity, not deducible from any that is fo
in the Ocean it self.

Yet all their Variety of Motions, wher
of *Top* or *Bottom* Springs, is commodious

supply

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ly'd, and kept on foot, by Rain; according to their different Exigencies; by the use of Reservoirs, to receive and retain it from Flood to Flood; fitted with Valves, placed in the Veins of the Earth, as in the Bodies of Animals; to Open by their Repletion, and again, by their own Weight, after every evacuation. A Theory that is made out by their successive Appearances of both Sorts, to be a Matter of Fact.

For an Instance of a Top-Spring, that varies both its Flood and the Time thereof, with the Weather: That, near *Settle*, fills with a Flood a Well four Foot long, three Broad, two Deep, in five or six Minutes; which again (its Sides and Bottom being leaky) runs out four Inches Water, in the like Space of Time; so long as the Wet Season continues; Which sooner grows Droughty, but the said Floods come gradually lessened and retarded; till at last the Extenuated Current, finding an easy Passage between the Valve and the Orifice (which it shuts not close) slides along its Channel at its own Rate. Evenly, without any Increase, or Diminution, sometimes for a whole Month together: While on the Contrary, the Bottom-Springs, which are constant and even in themselves, keep their Floods to the same Height, and Intermissions to an equal Measure: And That, in the Diocese of *Paderborn*, Remarkably, complies exactly with the Rising and Flowing of the Sea; in both the Respects; losing it self twice in four and twenty Hours, and returning back at the Interval of six Hours; and with such Violence, as

to

to drive *three Mills* : Yet, notwithstanding, not in the least Influenced thereto by the Surges of the *German Ocean* ; at *forty Leagues* Distance from It, and more than so many *Fathoms* beneath it : But must be supply'd entirely by the Clouds from Heaven, and full of its Intermissions from the Means above said. Its *Reservoir* collecting Water, in order to supply its Flood, with a *Valve* ponderous enough to with-hold it to its full Height ; and so close, as to lose its Stream twice in *four* or *twenty Hours* ; till the Raimy Currents force to return back again, after the Interval of *Hours* : With the same Constancy and Exactness, that the Sea Ebbs and Flows twice the said Space of Time : And by the Appointment of the same *Powerful and Provident Hand* which Created all things in *Number, Weight, and Measure*.

And, as for those Springs which, in *Force and Measure*, seem to observe the Motion of the *Tide*, because they are near the *Sea* it self, they must either lie below the *Flood-Marks*, to be Influenced by it ; Or else are fed by those Rivers that raise their Floods to so great a Height as to reach their *Level* : Or, if this general Reason admits of any Exception ; it must happen when the swelling of the *Sea, or River*, strikes the Passage of those Springs ; Or, least retard the usual Swiftness of their Descent, so as to make their depending Fountains Overflow, or swell Higher than Ordinary. Nor can it be any longer Objected, that those *Salt Springs*, which are found afar at Land, are either produced by the *Sea*, or communicate with It ; since the late Discoveries

very of the *Salt-Rocks* at the *Wiches* in *Cheshire*, where those Springs most abound and are impregnated by them: Nay rather, the *Sea* it self is beholden to such *Rocks* for its Briny Constitution; and doth not consist of One simple Element, but is a Compound of Two different Substances, to wit, of *Salt* and *Water*; which are easily separated, Each from the Other, by a *Filter* or *Alembick*; and as well by *Percolation*, as *Distillation*.

Others as vainly imagine, that an Excess of Heat, contracted in the Bowels of the Earth, vaporates Water (like Smoak) thro' the Clifts of those Mountainous Heights into the Open Air; and insist upon the Heat which affects our *Baths*, to confirm their Opinion: But in this Supposition, the Springs which are to be rais'd shou'd issue out of those Clifts, on the *Rising* Side; whereas daily Experience finds them still descending towards the *Lower*; as deriving their Extraction from a more sublime Origin, Heaven it self.

Nor does the Warmer Temper of those Salubrious Fountains, evince their Heat to be contracted from Elementary Fire; as being of too Active and Diffusive a Nature to permit any *Cold Springs* to rise so near 'em, as commonly to fall within the small Compass of the same Fountain; but rather derive their Warmth from the *Sulphurous Veins*, thro' which they pass; Or else, They are all impregnated, in their Passage, with several Minerals of disagreeing Spirits, which cause their Heat by fermentation; like *Antimony* mix'd with Sub-

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limate

limate; or Raments of Iron with Flours of Sulphur.

But, to allay the imaginary *Heat* of the last Opinion, it is thought by Others, that the excessive *Cold*, engender'd within the Earth, condenseth the *Air*, which is shut up in Cavities, into *Water*: And hence, They say, it is, that a Stone, or Plate of Metal, cast upon the Ground, where it is expos'd to the scorching Rays of the Sun, contracts a Moisture, by the Refrigeration of the Air, underneath; whereas they rather serve for a Cover to suppress the Steam, that wou'd otherwise breath out of the Earth where they lie, and vanish into Air; but for want of a free Passage upwards Thither, it is condensed into Water, by that Stop put to its Motion.

Or, in case either Vapours breath'd up, by an Excess of Heat, out of the Bowels of the Earth; or Air, condensed in those Caverns by extream Cold, gave Springs their Origin; the excessive Cold and Heat of the Winter's and Summer's *Solstices*, must needs respectively contribute to their Increase: But we find by Experience, that the Frost of the One dries them up, as well as the drougthy Heat of the Other; whereas the Rain of the Spring and Autumnal *Equinoxes*, where-ever it falls, Increaseth them in the same Measure; and after it is fall'n, leaves them upon as constant a Decay, as being their proper Cause; which, when 'tis Apply'd they immediately *Flow*; and when 'tis Remov'd they *Dry up* again, and vanish to almost Nothing.

And

And the *Thermometer*, at once confutes both these Opinions ; by stating the supposed Excesses of the Heat and Cold of those subterraneous Caverns, in a *Mean*, between the Extreame of *Winter* and *Summer* ; shewing manifestly, that the conceiv'd Difference proceeds purely from the different Disposition of Sense, as making an unequal Judgment at both Seasons ; excepting only in such Places, as are Actually set on Fire ; or where Mines of *Sulphur*, *Vitriol*, &c. abound : Yet their Heat no more causes the Springs that are found There ; than the Cold of *Lead*, *Alume*, &c. influenceth Those, that abound in other Places.

Lastly, Others insist upon many *Concurrent Causes*, for raising the same Springs ; or else, say They, if *Rarefaction* —, *Condensation* —, or the *Sea* —, did not jointly concur with *Rain* ; those Springs, that rise upon higher Hills than Showers can surmount ; or deeper in the Earth than They can penetrate, wou'd be weakly furnish'd ; but We have shewn respectively, in Both these Cases, that such a *Concurrence* wou'd be Impossible : Unless (as before admitted), they were surmounted by some Neighbouring Sea, or Constagnation of Water, that might supply 'em. Against which

Reply
It is *Rejoin'd* ; that *Pendle*, *Penigent*, and *Ingleborrow* Hills, (which are remark'd, by *Camden*, for the Three highest in *England* :) abound with Springs, beyond any sufficient Supply of *Rain* to recruit 'em : *Answ.* Whereas the Last, which distinguisheth it self from its Neighbouring Hills of an inferior Rank, by having

its tall Head mostly cover'd with *Rain*, or *Snow*, according to the Season of the Year, (while the Rest stand Bare and Dry,) tho' its Top be Flat and Level for a *Quarter of a Mile's* Compass; yet it has not any Spring upon it, till after some Yards Descent; and There but One, which might pass thro' a Quill: On *Penigent-Hill* appears no Spring at all, till after *Thirty Yards* Descent from the Top; which, tho' it be gather'd from a great Compass of Ground that lieth above its Orifice, yet its Stream little exceeds the Former: And as for the Eruptions of Water out of *Pendle-Hill*, which *Camden* takes notice of; but One of them has happen'd within *Thirty Years* Space, and then but of an *Hour* or two's Continuance; and 'tis supply'd by a *Bogg*, that covers the Top of the Hill; and only breaks out after long Surfeits of *Rain*, which cannot get sufficient Vent any Other Way.

It is Urg'd after all, that the Fountain which begins the East and West *Calders* near *Townley*, riseth so exactly on the Ridge of those Hills which separate *Yorkshire* from *Lancashire*, that it runs Both Ways at once. *Answ.* And 'tis no Wonder; being a large *Bogg*, which makes a Gap between Two *Mountains*, of *Thirty* or *Forty Yards* above its Height, which supply it with Water very commodiously; and 'tis so evenly seated, or rather Rising, in the Middle, as to send down its Currents on Both Sides at Once.

Yet these *Instances*, and so represented, have been receiv'd for Unquestionable Truths by the most Curious and Ingenious Observers of
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the *Wonders of Nature* in Those Parts ; and pass'd thro' all Ages for Unanswerable Objections against what has been here advanc'd concerning Springs ; and perhaps might have continued to be reputed such till the World's End ; if farther Enquiry had not been made into the Truth thereof, upon a special Occasion : Whence may be collected, what Credit ought to be given to Those many Learned and Grave *Authors*, who relate the like *Prodigies* of other Places ; and what is to be Reply'd, to their Accumulated Testimonies : Namely, that they took their Informations at first upon slight and ill-grounded Reports ; which, being once accepted *without due Examination* by their Ring-Leaders, pass'd for current Truths with all their Followers ; Who either made it not their Business to inform Themselves better ; or were never in proper Circumstances for that Purpose.

So plainly doth it appear from all that has been Alledg'd both *Pro* and *Con*, that *Rain* abundantly furnisheth all the *Fountains* in the World with Water ; without being beholden to such Imaginary Apprehensions, as that *Air* condens'd into Water by the *Coldness* of the Earth ; or *Vapours*, rais'd by its *Heat* out of its Bowels ; much less Streams convey'd thro' its Cavities out of the *Ocean*, can in the least Affect 'em ; but rather, *Rain alone* performs the Work : Which never Falls, but gives 'em an *Increase* in the same Measure ; nor is Withdrawn, but they suffer a proportionable *Diminution* : So vainly do we Grope at Noon-Day for *abstruse* and occult Causes ; while the

only True One is plain and *manifest* before our Eyes.

And as for *Top-Springs*, which ever appear to the Day on their own accord ; and *Bottom-Springs*, which lie absolutely buried in the Deep ; the Miner no sooner discovers *Where* they lie, but he infallibly determines *Whence* they come ; *viz.* the Former from Rain, distill'd thro' the Soil ; and the Latter deriv'd from 'em, by such Passages as the Quarries afford, to send 'em down into the Mines underneath : Nay, even Those which are found deepest in Places adjacent to the *Sea*, so rarely partake of its Influence, that it were as much a Paradox to say, (in general Terms,) that they proceeded from It ; as to Affirm, that Mankind were a *Blind Species* of Animality ; because some One Person might, perhaps, be found *Short-sighted*, in every Parish :

Which is but a weak and far-fetch'd Exception ; yet the only One, that either *Experience* can find out, or *Reason* admit to this general Rule : *viz.* That *Springs*, of all sorts whatever, owe their *Substance* and Being to the *Showers* and *Dews* which fall from Heaven ; their *Quantity*, both in Size and Duration, to the *Capacity* and *Depth* of those subterraneous Cavities which they penetrate ; and their specifick *Qualities* to the several *Metals* and *Minerals*, which embue 'em in their Travels thro' the Bowels of the Earth ; Let us proceed to the *Generation of Rain*, which is to supply 'em ; and to be again supply'd by 'em Interchangeably, for Ever.

CHAP. II.

Concerning the Generation of RAIN.

SECT. I.

*Of the Common Source and Production of Rain
in general.*

O proceed from the Discovery of the *Origin of Springs*, to the *Generation of Rain*; since Both alike consist of Water, as being Actually in Local Motion; the *Former*, still perpendicularly descending towards the Center of the Earth; and the *Later*, rais'd up vertically into the Air by the Beams of the Sun; to be let fall down again by the Poise of its own Weight; This redoubled Motion, affecting not only that small Portion of Water, which supplies *Fountains* and *Rivers*; but the whole Mass of Rain, which plentifully replenisheth both *Sea* and *Land*, throughout the Universe: My present Endeavour must be, to demonstrate How, and by What farther Means, so vast a Body of That heavy Element can be continually kept in Motion; still *Ascending* and *Descending*, by an ever repeated Reciprocation.

To give the First effectual Stroak for its Motion *Upwards*; the Sun, by the Intromission of his Rays, dissolves the Continuity of the Surface of that Water whence it was Extracted; and pares off what is more suble into small Particles of an Invisible Size; that, by a Division so Extraordinary, he may make a proportionable *Increase* of their *Superficies*; to hold 'em faster, and transmit 'em with more Ease thro' the vast Tract of Air they are to Ascend: As Bars of Iron, drawn into small Needles, will swim upon Water as Chaff; and a *Milstone*, pulveriz'd and scatter'd in the Air, may be tosd To and Fro, by every Blaft of Wind, like a *Feather*: And the Reason is, because Quantity *divided*, increaseth its *Superficies* in the same Proportion; tho' the *Substance*, or Matter contain'd therein, remains still the same, both in Bulk and Weight, that it was before the Division was made; so must also the *Subdivisions* proportionably increase in the One Respect (without meddling with the Other,) to an indefinite Progression.

But to whatever Number those Subdivisions be multiplied; or be those separated Particles extenuated never so much; yet still they remain *Heavier* than any equal Proportion of the Ambient Air; and, by Consequence, will not swim, but sink in it (as the Sediment sinks to the Bottom of Liquors;) Unless the Rays, which made their first Separation, being reverberated back from the Surface of the Earth, raise 'em up by their Rebound; and continually support 'em to the Height to which they were Advanced: So that upon
any

Of the Generation of RAIN.

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Abatement, either of the Force or Motion of those Rays, the said Particles must subside, sink down again to the Place from whence they Ascended; Those that precede still make the Way Easier, for their Followers to overtake 'em; and being Liquid, to *concorporate* 'em into a *double* Proportion Progressive. The first Composition consisting of *Two* Particles, conjoin'd; the second of *Four*, the third of *Eight*, the fourth of *Sixteen*, the fifth of *Thirty-two*, and so indefinitely; every Conjunction hast'ning their Fall, (in Proportion to their Weight,) into a greater Precipitation.

Thus Rain is Generated of *Vapours*, rais'd by the Sun; which become *specified* into several Sorts, in their Fall, by *Five* successive Concretions.

The 1st consists of the Primogenial Atoms of Moisture, of the *smallest* Size, and advanc'd to the *greatest* Height; which, condens'd by Cold of that Region, and being weakliest supported by the Sun's reflected Beams, at so great a Distance from the Earth, first begin to fall, and give timeliest notice to the *Barometrical* of the Change of Weather; but remain Invisible, like the Fall of *Dew* on a Summer's Evening.

The 2^d Concretion conjoins Two, or more of those Drops of the first Composition, into one; so as to overcast the Firmament with a *deep* Obscurity; which is express'd by the Sun, with a *Glaring Splendor* around his Disk; and the Moon, by a *Ruff* about Her secondary Light; while the Stars can scarcely peep thro' it; and Those, only Here and

Of the Generation of RAIN.

and There one, of the *first* and *second* M
nitude.

The *3d* condenseth into a *Misty* Obscure
which deprives us of the Sight of those G
Luminaries, tho' there appear no Clouds,
Gusts of Wind drive 'em on Heaps; wh
still grow more *Opacons*, till

The *4th*, rendring 'em no longer
portable by the Air, distills a *drizzling* for
thick and *Showry* Rain, consisting of a M
tude of small Drops; which, at

The *5th* and *last* Concretion, incorpo
themselves into *Rain*, in full Proportion :
this Account of the Generation of Rain, t
all its Descents, serves well enough for
Summer's Season; while the Weather is wa
and the said Vapours liquid.

But in *Winter*, when the Air is chill'd w
Cold, and those Vapours are benumm'd w
Ice, the Scene is chang'd; For

First, Those *Dewy* Atoms which rema
Invisible, now bespangle the Sky by t
smallest Size, and most regular Refraction
the Sun's Rays, with the glittering Bright
of a *white Frost*: *Next*, Each Two of
Points conjoyn'd, making a Line, becom
Hoar-Frost, and create a *Fogg-like* Duski
by their Irregularity: *Thirdly*, Each Two
these Lines laid together making a Pl
many of them interwoven into one Piece,
their fleeting Motion in the Air, (instead
Mist) become Fleeces of *Snow*; and *Fourthly*
These growing more ponderous and tumbl
down headlong from the Sky, rowl themse
into *Balls*; which *Fifthly*, bringing Frost al

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em into a moister Region, are crufted
with Shells of Ice, into *Hail-Stones*,
which makes the Operation compleat.

ow, in Regard the same Portion of Mo-
(which was *Rain* while it remain'd li-
became *Hail* by Congelation ; and Both
pally proceeded from Particles of the
est Size and rais'd to the greatest Height
the Sun ; and deriv'd their Pedegree from
thro' an equal Number of Descents, by
mpulse of their own Weight : It now
ers to shew, on the Converse, How they
daily remounted, by repeated Efforts of
ays, to the foresaid Stations ; and as it
regenerated, Each apart, without any
ction or Dependance on the Rest ; ac-
ing to their fundry Sorts and Sizes, and
Respect to their several Uses.

S E C T, II.

*Vapours, rais'd by the Sun to several Heights
the Air, grow, by their Descent, condens'd
to Rain, and Hail, of as divers Sorts.*

OW, suppose the Air to be purg'd of
superfluous Vapours, and the Sky ren-
serene and clear, by their Evacua-
The *First* Effort of the Sun's Rays exhales,
were by Respiration, the most subtile and
ute Particles of Moisture from all *humid*
Bodies,

Bodies, (as well as Lakes, Rivers, and Seas) but especially from Vegetables ; which gradually diffuse their Balsamick Odours thro' the Air till the Evening Sun, withdrawing his Beams, lets 'em fall again, almost imperceptibly, in the form of *Dew*, upon those Plants and Flowers whence they were Extracted ; or else they congeal into a *white Frost*, which asperses the whole Face of the Earth with a Mottled Tincture.

The *Second* Effort of his Rays, finding the Air begin to be warm, and the whole Face of Nature better dispos'd to be wrought on, penetrates deeper into the Earth, and draws up specifick Steams and Flavours out of Plants and Herbs of every Kind ; which are still carried up, Invisibly, to a greater Height, where they begin to subside perceptibly into a second set of Particles of the second Concretion ; which subsides upon the Leaves of Trees, and upon the Straws of Corn, in *Meldews* and *Hony-dews* ; if the Air be calm, and the Wind disperses 'em not : Or else in Winter, these Balls of *Dew* (being now coupl'd into Pairs) become congeal'd into a *Hoar-Frost* ; which breaks into a more Uniform Motion of Light into a *Dazzling Hazinefs*.

The *Third* Effort fetcheth up the Effluvia of Minerals, and sulphurous Exhalations, from the Bowels of the Earth, conjoin'd with the Vapours of as different Sorts ; which still, upon a greater Fall, grow into *Mists* ; or, when they hang suspended in the Air, become *Clouds*, being driven into Heaps by the Winds while the Weather continues Fair ; but upon

and Se the *Fourth* Effort of the Sun's Rays, or
 which ge her Lift by the Wind, the Weather chang-
 o' the ts Complexion into *drizzling Showers*,
 his Be d with Rain-bows, while they remain
 otibly, l; or into *Snow*, or *Sleet* of a Winterly
 d Flow position, mix'd with *Rain*; which, by
 else upervening Frost, are Cemented toge-
 n asper glazing the Earth with *Ice*, and loading
 n a M Trees with *Snow* intermix'd.

the *Fifth*, when both the Earth and the
 re impregnated with Heat, and jointly
 ire to reinforce this last Effort to the
 ft, and raise those Vapours and Exhala-
 to the highest pitch; and put 'em be-
 the Reach of the Sun's Power to sustain
 any longer; they Fall at last, with the
 est Speed and Precipitation, into *Show-*
Rain, or *Storms* of *Hail*, in a full Pro-
 on as to their watry Part; leaving behind
 the more Earthy Exhalations, of a more
 and more spirituous Extraction, to
 themselves in *Meteors* of all Sorts, in that
 er Region; which, by the Uneasy crowd-
 together of their Heterogeneous Matter
 divers Situations, condense, and fall in
 fferent Postures; and, taking Fire by
 Agitation, shoot into *Stars*, that vanish
 into a Line of Smoak; which (if it hap-
 y Day) leaves a *dusky Track* of Opacous
 in the Air, of three or four Minutes
 inuance behind it, Undispers'd.

ow, as to the different Manner of the
 position of *Rain*, and *Hail*; their first
 edients are alike Invisible Atoms, or Par-
 of Water of the smallest Size; which
 make

make their *first* Concretion into a *thin* *sture* by a scarce perceptible Descent; as the supporting Beams of the Sun (b overpower'd by their Weight) begin to y and the leading Particles still opening Way for the Others to follow and over 'em; condense at the *second*, into a *Fog*; the *third*, into a *Mist*; and at the *fourth* *fifth*, into Drops of *Rain* of several Sorts; increasing their Size, and Precipitation Proportion to the Depth of their Fall; w is found by Observation to be consider Greater in *Summer*, than in *Winter*.

But at their Conversion into *Hail*, the Invisible Atoms of Moisture are rais'd higher Region; where they are quickly netrated by the piercing Cold, and soon geal'd into a *Hoar-Frost*; just as Ramen Steel become glowing hot in an Instant, falling thro' the Flame of a Candle: And the frozen Particles beginning to Fall, are even spread upon the resisting Air, into Fleeces *Snow*; which still devolving Downwards, rowl'd by the Wind into *Balls*; and draw after 'em that Frosty Air, into a warmer mate below; are, by degrees, as it were c fited into *Hail-Stones*, of a larger Size; wrap'd in a Coat of a more Transparent, Icy Constitution; as *Candles*, dip'd in *Wax*, put on a new Investiture, upon e Immersion.

Hence it comes to pass, that *Storms* of happen so frequently in *Summer*, when H abounds, to raise their Vapours to a com tent Height; and so seldom in *Winter*, or F sty Weather, for want of Moisture to

a thin 'em together, as well as of Heat to
 nt; as 'em.
 Sun (b t, because the said Vapours, as soon as
 in to y Congeal, begin to Fall; and, spreading
 pening Fleeces, hasten their Motion, till they
 nd over owl'd into Balls of Snow; and are lastly
 a Fogg ed over with Ice, in their Precipitation:
 fourth e which are Higheft, and first undergo
 Sorts; Changes, get an Advantage above the
 itation, both for *Size* and *Speed*, in Proportion
 all; w eir greater Defcent thro' the warmer Air;
 onfider consequently, must receive an Accre-
 of the fmaller Sort, which are Cemented
 il, the m in their Fall: Hence it is, that *Hail-*
 rais'd are *rugged* and *Multi-Angular*, and of a
 quickly endent Brightness, contracted from as va-
 soon a Reflection of Light, (not *smooth* and
 Ramen like Drops of Water Congeal'd;) which
 instant expreffeth their different and manifold
 And p pofition.
 are ev nd, whereas the same Storm commonly
 Fleeces down *Hail-Stones* of several Sorts, and
 wards, ; and the larger and more rugged most-
 d draw all sooner; and the smaller and lesser Sort,
 armer wards; as being not able to pierce the
 were c and force their Defcent with the same
 Size; ed: And, when the Storm begins with
 rent, , and ends with *Rain*; it is because the
 in m , which caused that Precipitation in the
 oon ev mer and lower Region thereof, brought
 of Frost enough down with it, to cause and
 ms of B inue a total and perfect Congelation.
 then H ay, so convertible are those Watry Va-
 a com rs, that compose *Mists* and *Rain*, into
 r, or P w and *Hail*; and These are again so resol-
 e to e into *Rain* and *Mists*, that all *Four* are
 m sometimes

sometimes let Fall at once, out of the fa
Cloud, from their several Heights in the A
and with such Predominance either of H
or Cold, which as differently affect 'em ; th
while *Snow* is scatter'd on the colder *Tops*
the Hills, *Rain* is often pour'd down into
warmer *Valleys* below.

Or, on the contrary, after a Frosty a
Hoary Mist has long enshrowded the Ea
from the Beams of the Sun ; and they ha
melted the Upper-side of it into *Rain* ;
Showers, which were let fall, have no soon
touch'd the *frozen* Ground, but have be
Congeal'd, and glaz'd it quite over with
and loaded the Trees with a Burden there
scarce supportable : Thus Vapours, rais'd
the Beams of the Sun, and let fall by th
own Weight, are indefinitely diversified in
all Sorts of Weather, according to the Or
nary Course of Nature ; and perhaps all the
Changes may happen within the short Spa
of *eight* or *ten Days* : Let us see, how a
One Sort of Weather can be of a longer Co
tinuance.

S E C T. III.

How Fair and Foul Weather interchangeably succeed Each other ; and as diversly affect the Sky, at different Seasons of the Year.

SUCH is the Diversity of *Hail*, and *Rain*, and so various is the Weather depending thereon, at all *Seasons* ; that it is impossible to affix any Sort of it to whatever *Time*, or *Place* ; much less to continue it in the same State, upon reasonable Grounds, for a whole *Summer* or *Winter* together. Yet, since it sometimes so falls out ; and previous Dispositions, in a great measure, Occasion it ; and These are best taken from daily Observation ; I shall endeavour to draw a Scheme of the *Summer's Drought* in 1710, and How it broke ; compar'd with that Memorable one in 1681, (*Three and Thirty Years ago*,) in Both Respects.

The great *Drought* in 1710, began so early as the *fifth* of *April*, and lasted, without any considerable Change, till near the middle of *June* ; and persisted, without a Flood, till the beginning of *September* ; the chief Disposition for it being a wet and tempestuous *March* ; which at once disburthen'd the Sky of an excessive *Rain*, and settled the Air in a profound *Calm* ; till towards the Month's End ; when a cold *North-Westerly* Wind congeal'd those few Clouds, which remain'd undispers'd, into fleeces of *Snow*, with some few *Showers* intermix'd ; which left a muddy Sky for near a Fort-

E night

night within *May* ; which *overcast* the Heavens daily, from *Ten* in the Morning till *Two* in the Afternoon ; which the increasing *Heat* of the Air still rais'd Higher and higher, till it quite disappear'd and vanish'd out of Sight.

This Serenity continued *ten* or *twelve* Days longer ; the *Weather-Glass* keeping stedfast to its utmost Pitch all the while, to shew that the *Drought* of the Weather was then at a stand ; till near the Entrance of *June*, that the Weight of the Vapours and Exhalations overcharged the Sky, and became absolutely unsupportable : And that the Sun, having attain'd to the Height and Vigour of his *Summer's Solstice*, was as loath to let 'em Fall ; till the suppress'd Air began, as it were, to reel and stagger To and Fro, under the Burthen ; as plainly appear'd, by the various and Irregular Motions of some *wandering Clouds* ; which the *Barometer* also resented by a correspondent *Rising* and *Falling*, yet near to an *Equality* ; till those Clouds were *overgrown*, and subdued the Reflection of his Rays ; and forced the Returns of the *Sky* as well as of the *Quicksilver*, to decline gradually towards the *Falling* Side.

Yet they stoop'd not so low as to part with any Drops of *Rain*, till after many repeated *Descents* ; and Then, Here and There, contingently ; till those Clouds were driven into *flying Showers* by sudden Gusts of *Wind*, which still attended 'em ; and first they hit the *Ridges* of Hills, and *Heights* of Ground, that most oppos'd their Agitation ; and thence drove down into the *Valleys* ; where the Sun's Reflection was more broken and less able to sustain 'em, than in the *Plains* ; where his Heat was

Of the Generation of RAIN.

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so strong and Uniform as to *dispute* their Fall; and sometimes *repell'd*, and *resolv'd* 'em again into Atoms; and so *over-hastily*, and in such Crowds, that their Concretions grew so *fast*, and they fell again with such *Precipitation*; that they brought down with 'em from that *frozen Region*, at *Midsummer*, as sharp Blasts of Winds as usually blow in *March*; and as cold Showers of Rain, as fall in *September*.

And this Struggle between the *Heat of the Air* on the One Part, and the *Weight of the Clouds* on the Other, continued all *June* with an almost equal Success; and the *Impulse* of the Latter was so warmly *repuls'd* by the obstinate *Resistance* of the Former, while *July* lasted, that they mostly scatter'd *Mists* instead of *Showers*; nor did the Rain in *August* so entirely prevail over the *Drought*, as to cause a *Flood*, till near the middle of *September*: And after all, the Sky settled not into a Serenity suitable to the *Season of the Year*; but continued, as it were by *Counter-Libration*, those Ups and Downs of *Hot and Cold*, with *wet and dry* Weather, which happen'd in *June* and first Occasion'd 'em; whereas the *Other* Memorable One began *later*, and continued *longer*; and shut up the Summer's Heats with a seasonable Rain and a great Tranquillity.

For the said Droughty Season, being deferred more opportunely till *May*, the Rain, which fell in *March* and *April*, had time enough to sink deeper into the Ground, than to be overhastily extracted into Vapours by the Sun: Besides, gentle *North-East* and *West* Winds blew alternately all the while for his Assistance,

to support 'em, till the middle of *July*; and after they had got their full load of that *Opacous Stuff*; which, by obscuring the Lustre of his Beams and weakning their Fervour, reduc'd the Air to a *cooler Temper*; those Winds also began to vary, and shift more *Southerly*, to let them Fall by degrees, and condense imperceptibly into an *Overcast*; which, finding the substrate Air too warm to admit it *Universally*, ever and anon rose and clear'd up again, the Weather remaining *Dry* for all that Season.

Till, at the Beginning of *August* it scatter'd some *flying Drops*, of too large a Size to be dissolv'd and too heavy to be supported; as a Preliminary Disposition to the ensuing *Showers*, which were put off a *Fortnight* longer; and the Wind, now *veering* constantly about the *Horizon*, with the Diurnal Course of the Sun, thro' all the Points of the Compass in *Four and Twenty Hours*; kept the Constitution of the Sky so *Equilibrions*, and those Muddy Vapours so *evenly* spread over it; that, upon every Repulse from the Earth, they were *resolv'd* into Air in *two Hours* Space, and quite disappear'd; without any Evacuation of *Rain*, to carry 'em off; or one Blast of *Wind* to chase 'em away.

Until those *flying Drops* gathering together into *Showers*, and These falling in with sudden *Gusts* of Wind, broke the *Overcast* into *Clouds*; which respectively exonerated the Air, where it was heaviest loaden in the *First Place*, and successively proceeded to exonerate the rest; so that no where was miss'd: And, in Conclusion, the Resistance of the *Heat* below,
being

being every where weakned alike by the refrigerating Showers, fair Way was made for a plentiful Rain to descend Universally, till the Sky was clear'd, and the Ground satisfied.

So differently broke this Surfeit of Dry Weather from the Former ; and Both were so long continued, after as diverse a Manner ; and their more and less seasonable Commencements as justly Occasion'd it : The Former beginning in April, a Month too soon, and holding stanch no longer than June, contrasted a Change into Foul Weather with the Sun, upon harder Terms, when he was in full Power to resist it ; than the Latter (which was deferred till May) did in August ; when his drooping Beams easily stoop'd to lay down their Burthen : So that the Quarrel which was started at the First Change, and reviv'd at every Turn, in the One Case ; was either wholly wav'd, or readily appeas'd in the Other.

Hence it is Remarkable : 1st, That, in both Instances, the Serenity began and ended with a dusky Sky, for ten or fifteen Days together ; with an Interval of settled Weather for five or six Weeks ; the precedent Dusk alike beginning, and the subsequent ending with Rain, which Occasioned the Change.

2^{dly}, That those Clouds rose every Day till Noon ; and fell in the Evening, while the Fair Weather was coming on ; being advanced by the Morning-Sun, and let fall by his Westerly Declination ; while the Air was cool, and the Earth moist to receive 'em : But, on the contrary, when the Serenity went off, the said Cloudy Overcast still descended from the Air's upper

E 3

Region,

Region, till the Sun's *Noonstead Height* enabled him to repel it, whence it came.

3dly, That the *Rising Overcast*, the higher it was advanc'd the thinner it became, and more *transparent*; till it quite disappear'd: Whereas, on the contrary, That which *descended*, the lower it sunk and the nearer it approach'd to the Ground, grew more dense and *Opacous*, till it was repuls'd.

Lastly, That how dense and gross soever this *descending Overcast* became, yet it was usually clear'd off, by a Resolution into its *primogenial Particles*, in *four Hours Space*; that is, between *twelve a Clock* and *four in the Afternoon*; having the remaining *twenty Hours* allow'd it to Compound again, before it was resolv'd a *second time* by the Sun, when return'd to the same *Meridian*: Till at last it was dissolv'd into *Mists, Showers, and Rain*; and the Serenity ceas'd.

Thus *Rain*, in both Instances, was Generated of *Vapours* rais'd by the Sun; which pass'd and repass'd thro' all its *Degrees of Concretion and Dissolution*, recounted in this *Section*, by the superadded Tendency of its own Weight, within the short Space of *four and twenty Hours*: The Weather continuing *Fair*, while they were supported by his Rays, in *Summer*: Now it occurs to enquire, How such Weather can be settled in *Winter*, while his warmer Beams are withdrawn to a Foreign *Climate*,

SECT. IV.

*How the Weather becomes settled in Winter ; and
changeth differently from what it did in Summer.*

FROM what has been said already of the Change of the Weather in Summer, it plainly appears ; that it is *Then* best settled (when the Heat of the Sun is predominant) by his Support of those Vapours and Exhalations in the Air ; which otherwise would decompose it : *Now*, on the contrary, the like Serenity is best preserv'd, when those Vapours and ill Humours are let fall to the Ground, and suppress'd by a hard Frost ; to breed no Disturbance, till his warmer Beams lets 'em loose again into some New Commotion.

For, to resettle a *Winter's* Serenity, after the *Autumnal Rains* are Fall'n, no more is required ; than that their Moisture, after it is sunk deep into the Ground, be Congeal'd There, while he declines to his *Winter-Quarters*, to give the Air no Disquiet ; till his reascending Beams begin to rouse 'em up again, towards the Spring, into Fogs and Mists ; which the sooner it happens, the Change of the Weather grows more *Tempestuous* ; and the Rain, being grosser, falls with greater Precipitation ; Or else, if the Season be farther advanc'd, the Frost commonly breaks into Fair Weather ; the same Heat which raiseth those Mists being enabled at once to dissolve, and support 'em.

Our last *Great Frost*, and its *sudden Thaw*, was a Memorable Instance of the *Former Sort*; which continued, with some Intermiſſions, from the Beginning of *November*, till the End of *January*; and, after it had enſhrowded the Earth from the Rays of the Sun, for *eight or ten Days*, with a thick *Hoar-Froſty Sky*, broke ſo on a ſudden; that the *Thames* was paſſable for *Coaches*, from *Weſtminſter* to *Lambeth*, in the Morning, and for *Barges* back again before Night; the Sun's Rays having warm'd the *Backſide* of that *Miſt* all thoſe Days (which was congeal'd before, and floated thro' the Minuteness of its Particles,) then (being made liquid) concorporated into ſeveral Concretions, and ſunk down apace, till it had melted all the Reſt.

Another Froſt, about *ten Years* before This, (which continued from the *fourth* of *February* till the *twentieth Day* of *March*) froze it ſelf out of the Ground, without *Rain*; the more enlivened Beams of the Sun, at ſo far advanced a *Season*, ſtill carrying off the *Foggy Vapours* and *Froſty Exhalations*, as ſoon as they were rais'd; and leaving an Interval of a happy *ſeeding* (which was ſucceeded by an early *Harveſt*,) before any *April-Showers* fell to interrupt it; quite contrary to the *Other*, which broke in the *Depth of Winter*, with a *baſty Rain*; the Air being then groſſer and heavier, than the Sun was able to ſuſtain.

Thus *Fair Weather* is of *Course* ſucceeded by *Foul*; and cannot be long continued, in *Summer*, without an *Exceſs of Heat*, to ſupport thoſe *Vapours* and *Exhalations* which float upon

our Air; nor in *Winter*, but by as intense
d, to suppress 'em: But in the *Spring* and
mm, when the *Equinoctial*-Sun stands Neu-
in Reference to those disagreeing Qua-
; *Wet* and *Dry* Weather change alternately
every Turn of the *Wind*, without any
spect of Settlement; till either *May* gives
Predominance to the Former, or *Novem-*
to the Latter; and seldom without violent
be-orms, and raging *Tempests*; which, being
rm'd *Compound Meteors*, consisting of *Wind* as well as
nich, they properly belong to the following
Mi-*tem*; where *Both* are jointly discuss'd, and
made various *Phænomena* are disclos'd and Ex-
cre-ated.



C H A P. III.

Of the Production of WIND.

S E C T. I.

The general Notion of its Production.



ALTHO' Rain (of which I already treated) and Wind (which I now undertake), be composed of Two different Elements; yet they sympathize so much in their Productions, that what I have said of the Generation of the One, must in part be repeated, and apply'd to the Production of the Other; for Water is rais'd vertically, in the Former; Air, in the Latter; and Both entirely, by the Rays of the Sun; notwithstanding, as to the Manner of their Descent, they differ not in regard the Air which they pass thro', not transmit 'em alike; So that my present Endeavour must be mainly employ'd, to compare 'em together all along my Discourse; shew at every Step, their Accord in the One respect, and their Difference in the Other.

CHAPTER

First, Concerning their joint Accord: the first Active Stroke that the Sun gave in the Generation of Rain, was to extract Vapours

ter, by a Dissolution of its Continuity
small Particles; that by the Increase of their
cies, he might hold it faster, and raise
o' the Air with more Ease: So, in the
tion of Wind, he mingleth his purest
with the grossest Air, which grovels
the Surface of the Earth, to make it
by their Composition; and withal to
it to a greater Height, Spherically; still
ing it more and more below, and Con-
it as much above, as the Reflection of
ays either Increaseth or Diminisheth; and
is also renew'd by a daily Repetition;
t last they grow too weak, to sustain so
a Load of Exhalations any longer;
n then begin to Fall again, towards the
ce of the Earth, depress'd by their own
it.

Secondly, Touching the different Manner of
Descent, the Water, whereof Rain con-
being a much denser and heavier Ele-
than Air, (the Medium thro' which it is
is,) every Drop thereof must pierce it
a distinct Hole; to distill its Showers per-
cularly towards the Surface of the Earth;
reas windy Exhalations, how gross and
y soever they be, yet still retaining
Natural Context of that Element, they
drive the Subject Air entirely down be-
them; as the Salt-Flood repels the Fresh,
n their Currents meet; and (the depress'd
still making a more obstinate Resistance)
Part of it which is the Uppermost must
aside, to find an easier Passage Downwards;
the faster it falls (always meeting with a
ter Resistance) it is still constrain'd to de-
scend,

scend, by a greater *Declivity* from the *Perpendicular*; till its *Course* arrives at last to a *Level* and becomes *Progressive* ever after; the *Stream* of *Exhalations* pursuing the same *Track* and *pushing forward* all the while, till the *common Stock* be quite exhausted: Thus *Wind* is produc'd, by a *reciprocal Motion* of *Exhalations*; first *Ascending perpendicularly*, then *Descending* again still more and more *obliquely* by degrees, till its *Course* becomes at last *Horizontal*.

And forasmuch as the *Wind*, according to the *vulgar* Acceptation of the Word, is understood, *A Flux of the Air*, which is the *Subject* of its *Motion*; in Reference thereto, it is to be

Consider'd, *First*, that *Air* is a *Heavy* Element; as appears by the *Baroscope*, which is the *purest* Sort *Equilibrious* to *seven and ten Inches of Quicksilver*; or so many *Foot of Water* and, consequently, the most *natural Motion* of the *Wind*, in Compliance with the *Tendency* of its said *Subject*, must be *Perpendicular*, towards the *Center* of the *Earth*.

Secondly, the *Wind* being rais'd *Spherically* by the *Sun*, with due *Respect* to our *Globe's* *superficies*, must *Fall directly* towards its *Center*. And being also *puff'd up* by the *Composition* of his *Rays*, must return back as *directly* where it came (as *Air* returns in a *Cupping-glass* when the *Flame* is *Extinguish'd*), as soon as they are *withdrawn*: Beside, the *Reflection* of his *Beams* being *strongest* near the *Surface* of the *Globe*, which they fall upon; the *windy Matter* must make the *sharpest* return *Thitherward*: Hence

Perpetual Descent create the *briskest Winds*; as is the *sharpest Showers*.

Ordly, To decline the Course of the Wind; as the Rain, that falls indifferently in Places, alike *slides down on all sides* into Valleys, so does Wind into the same Depressions; and as Rivers of Water are directed to their Banks; so is this Flux of Air by the Direction of the Valleys, which it chanceth to follow; the One Element, being as naturally inclined to follow the Conduct of its own Force, as the Other; And Wind grows, by its steepest Descent, as it were into Floods, still larger and stronger Stream.

It is on Plains and Champion Ground, where Depressions are found to sway its Course; as the heavier and denser Air (being Uppermost) holds its Way thro' That which is Lower and lighter; so the Heavier Side of any Part must incline to the Lighter side-ways after it; or the lighter Side of the substrate Air must incline it self down that Way; while Exhalations render it unequally Ponderous, by their Compression; or the Vapours, which attend it, destroy its Indifferency by Protrusion: But, both the Upper and Lower Air being withal Elastic, the Motion of the One is broken disorderly interrupted by the Repugnance of the Other, without End or Measure; while, for want of any Determination, the Wind runs around, at many Times, in vain to find one, till it be

At last, the Sun, which first stirs up this Turbulence in the Air, by Rarifying it below, and Condensing it above; draws it after him from East

East to West, by leaving it still *Rarified* by its Presence, for the *More dense* to follow him by its *Preponderation*: All which said Points cur to be *discuss'd* and *explain'd*, in the Order that they are *Propos'd*.

S E C T. II.

How Wind is produc'd of Air, by the Mixture and Mixture of the Rays of the Sun, How it is directed by the Situation of the Earth on which it falls.

SINCE *Wind* Essentially consists of *Air*; and all Motion is conceiv'd to proceed from *Rest*; I am to suppose the *Air* to be settled in a profound *Calm*, before it begins to Move; and shew how the *Rays* of the Sun first disturb its Quiet; partly by the *Light* of their Composition, expanding and raising it, as it were, towards a *Vacuity*; partly by the *Activity* of their Reflection, raising up the Groffer Part of it in the Morning while their *Light* and *Heat* increase; and then sinking it *sink down* again into that *Vacuity*, when they are withdrawn in the *Afternoon*; which sufficeth to answer the *Wind's* aforesaid Production.

Thus the *Air* is rais'd by the *Mixture* and *Activity* of his Beams upon the first Approach and falls again Perpendicularly, as soon as they are withdrawn, by the *Innate* Propensity

of its own *Weight*; but withal being ex-
 ly *Liquid*, is as easily inclin'd to follow
 different *Direction* of the *Ground's Declivity*,
 ever it lights: Hence it comes to pass,
 the *Morning* and *Evening's Air*, constant-
 tends the *Rising* and *Setting Sun*, with gen-
 les, upon the plainest *Flatts* of *Ground*,
 midst the greatest *Calms*; breathing eve-
 where, and every *Way* at once; and al-
 as *Imperceptibly* as the *Rise* or *Fall* of
 and scarce to be discern'd, but by the
 ing *To* and *Fro* of the *Flame* of a *Candle*;
Weathercock-like, wou'd represent the *Va-*
 of its *Motion*.

, upon a considerable *Advantage* of
 nd, the *descending Blasts* grow sensibly
 n'd; and if its *Declivity* be increased in
 or *Compass*; the *Wind* makes more haste
 it, and spreads it self into a *larger* and
 Stream, towards the *Falling Side*; as
 are wont to swell, and subside towards
 into the *lowest* *Situations*, while the
 calm, and leaves 'em *Undispers'd*.
 nd, when they draw their *Extraction*
 aloft the *Hills* which surrounds those
 their *Celerity* is increas'd, in *Propor-*
 to their *Descent*; and they slide down, suc-
 y, wely from all *Sides*, into the deepest *De-*
 ons; where, like *Torrents* fed with many
 and those also swell'n with *sudden Show-*
 they rush headlong down the *Valleys*, into
 rains below; and as it were *Overflow*
 with *Inundations* of *Windy Matter*; like
 over-grown with *Rain*, when their
 are broken down, and their *Channels*
 Prop capable to contain 'em any longer.

But

But if it chance, that the Vapours and exhalations, whereof the *Wind* is composed, mount the *Tops* of those *Hills*, whence they derive its Origin; They *rendevouz* the while, with a great deal of *Indifferency*, they be *broken* by their own Weight, upon the *Summits* thereof, into several *Parties*; and descend as *divers Ways* at once, into Streams as *different Determinations*, according to the *Conduct* of the many *Valleys*, they fall in whether down into the *Plains underneath*, they be carried *farther off* into *Foreign Countries*: As from the *Tops* of the *Carpathian* in *Hungary*; where the most *Eminent* of them, having scarce a *Breathing Air* upon it, give Beginning to the *manifold Streams* that issue thence, in the *Valleys underneath*, into *Floods* of Air, that become most violent and *Intemperate*.

Or, if the *Tops* of the surmounted *Hills* be *Ridged*; or many of them continued in one, the said *Mass* of *Condensed Air* sometimes splits itself into the *Two contrary Winds*, which blow from each *Side* at once, toward the *Opposite Points*; as the *East* and *West Winds* frequently do from that *Ridge of Hills*, which separates *Lancashire* from *Yorkshire*; by the impulse of the condensed *Body of Air*, that chargeth it self *Both Ways*, till some *Counter-motion* of the *Air* repel it; the like being done by some *Hills* and *Winds* in *France*, and other *Places*.

Or, if the *Form* of those *Hills* be *Pyramidal*, their *Tops* being *Piqu'd* and their *Sides* *smooth*; the *Bodies of Wind* which surmount them, being *pierced*, descend every way all

with so much *Indifferency*, that the Diurnal Motion of the Sun, rarifying the Air successively before 'em, sufficeth to draw 'em correspondently from *East* to *West*; from *Morning* till *Evening*, that He lets 'em fall; as is reported of Mount *Viso*, that over-tops the *Alps*: And perhaps the *Wind*, being drawn so far as One half around it, may compel the Air on the back-side of it, to blow the contrary Way along the *Other half*, to perfect the Revolution.

But it happens much *Otherwise*, when a ponderous Mass of condensed Air is let fall by the Sun from the Top of a High Mountain, without any such *Predetermination*; as is done frequently, from the Top of *Parlock* near *Manchester*; where the *Wind* tumbles down into *Cyresdale* with such *Precipitation*, that, by its rebounds from the Bottom of that Valley, it remounts the *Westerly* Heights of Ground; and is carried aloft to near the same Height, till it fall into the *Sea* some *Miles* off; while the *Westerly Gales* have blown underneath it, for some Time, the contrary Way; as appear'd by the Clouds, riding *Both Ways* at Once.

Thus out of a profound *Calm* is drawn a *breathing Air*, by the Beams of the Sun mixing with it; which, being enliven'd by their activity, first *ascends*; and, after They are withdrawn, is let fall again by its Flux downwards; which gives it the Nature and Notion of *Wind*: And the *Reflection* of his Beams, being strongest near the *Earth's* Superficies, makes the lower Part of it *Lighter*, to incline it to fall; and withal more *Expanded*, to make room

room for its Reception: Now being thus disposed, and exquisitely *Liquid*, it must as easily follow the least *Declivity*, where it Falls; and the *Higher* it is mounted, still with greater *Precipitation*; and the farther the Valleys are extended, either in *Depth*, or *Breadth*, still grow into greater *Floods*, and Flow more *impetuously*, according to their *Direction*; as appears by those *Instances* I have produced for that purpose: Hence it is to be Concluded, that *Wind* is nothing else but such a *Flux of Air*, as I have described.

S E C T. III.

How the Motion of the Wind depends on the unequal Poise of the Air; and How its Flux is diversified, in its Passage thro' It.

SINCE the *Wind* is defined a *Flux of the Air*, and the *Air*, so moved, is a ponderous Element, as appears by the *Baroscope* (which makes the Weight of the *Atmosphere* when it is *lightest*, equivalent to seven and twenty Inches of *Quicksilver*) no more is required from the Sun, to convert it into *Wind*, Than first to *Rarifie* the *Air* more below, by the Briskness of the Beams near the Surface of the Earth, and swell it up *Spherically*, by the Mixture of his Rays: And afterwards, by withdrawing 'em again at his setting, to *condense* it above, to make it *Heavier*, to *Fall* perpendicularly towards the Center, and supply the rarified Space left behind

behind Him : Just as after the enkindled *Flax* as expell'd the Air out of the *Cupping-glass*, it returns immediately, to replenish it again, after the Flame is extinguish'd : And withal, since the Sun draws, all the while, the said rarified Space after him Transversely, into the West, by his *Diurnal Motion* ; the Wind must needs follow him Thitherward, to satisfy its above-mention'd Definition.

Yet, notwithstanding this *Easterly Determination* of the Wind ; the Sun, to leave it free liberty of Blowing from any other Quarter of the Heavens, in this our *Temperate Zone*, (where his Rays are weaker, and his Course of a smaller Compass than in the *Torrid*) and also to direct its Motion more effectually, from every Point of the Compass, on Occasion ; permits it either 1st, To follow the *unequal Poise* of its own Weight towards the *Heavier Side* ; 2^{dly}, To fall into the *substrate Air*, where it is weakest, and least able to support It.

First, Concerning the *Former Part* : To observe the Motion of the Wind both Force and Point, at the same Time ; the Sun, from his Rising to his Setting, ceaseth not to fill the Air with *Exhalations* and *Vapours* ; which, consisting of *Earth* and *Water*, tho' divided into the smallest Particles, still preponderate the Ambient Air, and press it downwards ; as neither being *Lighter*, nor filling a greater Space by their Separation : Again, That windy Matter being diversly extracted, both for Quantity and

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Quality, Here and There, out of wet and dry Places ; must as differently affect the Incumbent Air, to move *Transversely* ; and pursuant thereto, give the *Wind* as various a Propension towards all the Points of the *Horizon* ; and not less effectually Here, on *Champion Grounds* than the Declivity of *Hills* and *Valleys* actually do in Other Places.

And, whereas *Exhalations* are so finely intermix'd with Air, as to give the *Wind* an *Interior* Tendency by their *Compositions* ; and *Vapours* are only annex'd to it, to impel it *Exteriorly* by *Protrusion* ; yet, forasmuch as their *Natural* Propension, draws 'em Both *downwards*, They jointly concur to the *Wind's Production* and *Conduct* ; seldom descending apart : After the One has *Open'd* the Passage, the Other still making more haste to pursue and overtake it ; and mutually propagate each Other : The *Wind* by condensing the *Vapours* into larger Drops of *Rain* ; which, by growing greater, and falling faster, on the *Converse*, hasten the *Air* into *Wind*, to supply the same Space and restore the *Air's Equilibrium*, by their *Precipitation*.

Thus the *Wind's Indifferency* which way it Blow, is effectually determin'd by the *Unequal Poise* of its own Weight ; and its Flux is directed by the *Uneven Support* of the *Air*, which sustains it : Now, altho' the *Passive Part*, through which the *Active Wind* is to force its Way, is exquisitely *Thin* and *Fluid* ; and more slippery than Ice, to let it slide down over It ; and easily stoops to its *Pressure*, on the declining Side, if gently Mov'd ; yet it grows harder by *Compression* ; and *Obstinate*, if it be urged

w

ich Speed and Force : And the Air (like Water mix'd with Wine, or Balm and Oyl with other Liquors) is never quiet and at Ease, till the heaviest Part be Lowest seated ; and all the rest in their proper Stations, to render the whole Body throughout Equilibrions : Hence is, that, as Rivers of Water are confined to their Channels ; and their Streams are regulated and directed by their Banks, which Way to move, whither to Flow, and after what Manner ; so, in our present Case,

§. 2.

Secondly, The Flux of the Wind must concede the Favourable Disposition of the substrate Air, all those Respects.

First, If the Airy Matter, whereof the Wind composed, be advanced so High, and the substrate Clouds prove so gross, as to render its Motion perfectly Level before it reach the Surface of the Earth ; it hurries those Clouds along with it through the Sky, at near the same Height, at a mighty Rate ; (Nothing that is steadfast or solid occurring, to obstruct or retard its Career,) notwithstanding the Rack may ride underneath perhaps Transversely, or the quite Contrary Way, by Virtue of a like Impulse from some other Quarter of the Sky ; till all the said Winds subside into Calmer Weather: Or,

Secondly, In case the Weight of the Wind prevail, to force its Descent down to the Ground (as is usual) Obliquely ; it rebounds again into the Air at near the same Angle ; and is Reciprocally brought down again, by its Preponderation, through the Ambient Matter ; and so Up and

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Down, with a kind of *Undulation*; moving forward (like a full-blown Bladder cast upon a Marble Table) with progressive *Subsults*, till the Energy of its *first Impulse* be spent.

Thirdly, If peradventure the *Descent* of the Wind be so deflected from the *Perpendicular*, as, at its Approach to the Earth, to sweep the Plain whereon it lights, with a smooth *Horizontal* Gale; yet presently its Flux becomes disorder'd, by its Adhesion to the Ground; which being fix'd, retards its Motion below; while the Fluidity of the Air aloft, devolves it with more Freedom, as to the Upper Part; which, like a Bowl cast upon a Plain, moves forward with *Cycloidical* Furls, one wrap'd within another, till its Motion ceaseth; which, like Waves of the Sea driven into shallow Water, tumble headlong One over Another, as if they stumbled upon a broken Bottom.

Fourthly, Though the Flux of Wind (all the said Impediments being remov'd out of its Way) had free Liberty in other Respects, to blow to every Point of the Compass, without any Difference; yet it cou'd not pass forward towards any of 'em in particular, without slipping aside, and making its Returns To and Fro alternately at every Instant; the Passive Air still making the greatest Resistance to the Active Wind's Motion in a direct Line, where it is most Oppress'd: And the Wind being also in Readiness, and well prepared to slip aside into the easiest Passage, it creeps forward with *Serpentine Windings*, without Intermiſſion: Hence the Weather-cock changeth its Point at every Blast while the Wind passeth on its Journey, as a Ship under sail does its Voyage; which busied

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the Rudder to keep it as close to its main Course as is possible, yet never steady.

Lastly, Superadd to these manifold Deflections of the Wind the Elastick Force of the Air; and those Streams, which have run silent and continuous all this while, are presently broken into rough, and frequently interrupted, Blasts; which grow more noisy and tumultuous at every Turn; and upon any Resistance, exert themselves into braker Efforts, to beat down all Opposition: And after One Rush is over, they take the Advantage of the Calm, to recollect their Forces and prepare for Another; and so for a Third, Fourth, Fifth, &c. while the Tempest lasteth.

Hence it is Observable, that in the Calmest Air and after the longest Intervals, they exercise the greatest Violence; and make more sudden and surprizing Eruptions in the Beginning of a storm, when they are most resisted, than after the Air is render'd compliant with their Agitation; and still they become more fierce, while it remains clear and free from Vapours, not to log their Efforts: Yet never attain to the full Exercise of their Authority, till the Air (as in Wind-Guns) be compress'd alike by contrary Blasts, on all Sides together.

Hence the Motion of the Wind is render'd so various and inconstant, as not to be traced and delineated but by it self; yet, 'tis represented more visibly to the Eye, as it is audible to the Ear, or tractable to the Hand, by the concomitance of a Train of Smoak, chased thro' the Air by a gentle Breeze: By which, all the Diversity of Up's and Down's, To's and

Of the Production of WIND.

Fro's, Backwards and Forwards, are drawn to the Life upon the Canopy of Heaven: And altho' they all proceed from the Few Causes which I have already Assign'd; yet their Efforts run so variously and contingently intermix'd at every Turn; producing such a Diversity of odd and irregular Postures, and Figures of Instancy; that no License of the Painter's Pencil, directed by the wildest Strains of Poetical Fancy, can reach to describe it at Land.

And

§. 3.

Concerning the *Winds* which are raised *at Sea*; They wander thro' the same Wilderness of *Instability*; its Superficies being *Plain*, without any *Eminences* to give 'em Fall, or *Depressions* to direct 'em, like *Breezes* upon *Champaign Grounds*; And are mov'd *To and Fro* with so much *Indifferency*, that if they be not repuls'd at their Entrance into *Creeks* and *Rivers*, by stronger *Land Winds*; they constantly set into 'em with the *Influx* of the *Tide*, and with its *Reflex* retire back again.

And if those *Sea-Winds* consist of stronger *Blasts*, and be withal *Outward bound*; They are as much beholden to the *Heights of Rocks* or *Boldness of the Shores*, for their *Force* and *Speed*, as if they had *Blown at Land*: And for their *Horizontal Determination*, they depend not so much on the *Flux of the Streams and Currents* underneath, while they keep within the *Soundings*; than *Land-Winds* do on the *Declivity of Hills*, which give 'em Fall; and on the *Cavity of Valleys*, which receive 'em.

And

are alike *diversified*, with Respect to Both, their *Sorts* and *Sizes*, as long as they are in'd within the Limits aforesaid. And if those Winds be rais'd so far off at Sea, neither *Coasts* nor *Currents* can increase *Force*, nor influence their *Direction*; the by the *Uniform Reflection* of his Beams the Ocean, performs *Both* no less Effect; by raising an *Effluvium* of Vapours exhalations into the Air, in as great Assistance, while he is *Present*; and letting it down again in his *Absence*, with as much evaporation at Sea, as any where else: And lifting his *Annual*, *Menstrual*, and *Diurnal* motions, their own Ponderation still pursuing course, gives 'em an endless *Diversity*, conjoined with an absolute *Determination*; the Earth's Superficies being *plain* and *smooth*, to afford a free and easy *Passage* for every Blast, in the rough and rugged Surface of All things as *Obstinately resists*; That makes them, the most *constant* and *Uniform* of all Objects, and to reach the *farthest Distance*; and with what *Variety*, more hereafter.

Generally, The *Wind* as well as *Rain*, both at Sea and *Land*, depends upon so many various *Contingent Circumstances*, throughout the *different Zones*; that as those *Showers*, spoken of before, were *dispers'd* Here and There, by clouds, with an *indefinite Diversity* of *Quantity*, and *Duration*: So their concomitant Blasts of *Wind*, were proportionably diversified in the same *Respects*: But add thereunto a farther Consideration; viz. That every small Portion of *Air*, whereof those Blasts consist, is *indefinitely Compressible*; on the One Side,

Side, by what *drives* it forward ; and on the Other, by what *resists* it ; and they must exert their *Elastick* Effort, with so different Speed and Force against that *Restraint* : perhaps no *Two* of 'em were ever the same in all those *Respects*, since the *Creation* : to add Force to their *Variety* ;

S E C T. IV.

Of the Production of Storms and Tempests

AL L that has been hitherto Discours'd of the Nature of *Wind*, and the several Determinations of its *Course*, is no more Ordinarily happens, on all Occasions, in reference to the *Poise* of its own *Weight*, inclining it to *Fall* ; and the previous *Dispositions* of the *substrate Air*, to admit and direct it, as the Substance of its *Motion* : And, where we have all along Treated the *Exhalations*, whereof it is compos'd, as *Principal* ; and *Vapours* whereof *Rain* is made, only as *Accessory* : I now to describe *Storms* and *Tempests*, which equally consist of *Both*, either *conjoin'd* or *separate* : I am to respect 'em as such : And, in Relation to *Vapours* are *visible*, and *Exhalations* are not ; I begin with the Former, to explain the latter, which are *invisible*, as consequent to the former way of Explication.

Now, as those *Rainy Vapours*, when, after a longer Continuance of *Fair Weather*, they are rais'd *Higher* than Ordinary ; as they are

in Height, so they are enlarged, and into Clouds of a greater Compass, from the Access of fresh Recruits, and this Visibly: may infer, that their concomitant Exhalations do the like, and Embody themselves, after their Invisible Manner: And as those of Vapours sometime grow to Overcast the Air; 'tis reasonable to subsume, that Bodies of Exhalations become Co-extensive to them; even after both, by their greater Exhalations, are vanish'd quite out of Sight: Whence follows, that as those Clouds become visibly, Storms of Rain; which Fall suddenly, and soon spent: And that Overcast suits with Tempests of a longer Continuance, and a larger Force: So, by Parity of Reason, these Exhalations must supply both Storms and Tempests, as the Windy Part: Let us see how the Operations perform'd, in every Respect.

§. I.
Concerning the Production of a Wind: The Vapours and Exhalations provided begin, even while they are yet Invisible, and towards the Center of their Gravity, the Lines of their Accumulation are the same, and consequently make the deepest Impression into the Air underneath: And the Rest being Thither from all Sides at once, (as Water poured into a Tunnel, sinks into its Spout,) multiply their Concretions into the great Drops, which condense at last into a Cloud: where they are discharged headlong into a Torrent, till (their Evacuation exceeding their Concretions) the Alleviated Air shuts itself up again;

again; while *the rest* of the Stormy Matter, which remains, tending towards *the same Place*, prepares it self for *another* Eruption.

For, the *First Effort* of the Storm, having carried off all its Watry Part that was designed for it, and every Drop, as it fell, leaving a Hole *shut thro'* which it pass'd; the Wind, pursued it before, is now put to a stop; and the Air is rendred *stagnant* and *serene*, till the Remains of the Stuff, which was left *unprepared*, tending to the Center of the precedent Evacuation, and coming into a *Narrower Compass*, repeats successively all the *aforsaid* Concretions, till it be dissolved after the *same Manner*, pursuant to the former; and so a *Third Effort* succeeds the second, and a *Fourth* the third progressively, one following another with the *like Intervals*; till the Sky be quite rid of all *superfluous* and troublesome Matter, to give the Air any farther Disquiet.

And, in case the *Welkin* be dispos'd to let such Storms fall, in *several Places* at the *same Time*, they breed no new Disturbance in the Air, while they follow the *Course of the Wind*; but if they vary from it *divers Ways*, the Air becomes *tumultuous* on their Occurrence. And if their Motions prove *Adverse* to one another, their Rencounters grow more violent, whether so directed at their first Eruption, or induced, by their own Weight, to fall into some Emptiness in the Air below; where they Insult each other so outrageously, as, in the Congress, to rid up Oaks by the Roots; and to throw Castles, by shocking the Earth and shaking their Foundations: Nay, sometimes swallow up whole Armies, by assaulting 'em from

Quarters of the Heavens at once, with an
 terrible Indignation.

When but One single Storm, how fierce soever
 sets against the Wind, the Conflict is not
 long, being much abated by the Defendant,
 the yielding Side; yet becomes more Dread-
 ful by the Addition of Fire-Arms to their Fury,
 especially amidst the Heats of Summer, while
 the Air is, on all Sides, impregnated with sul-
 phur and combustible Matter; which Both
 sweep together in their Encounter; and
 compressing it into a Ferment, and overheating
 their Agitation, makes it take Fire, and
 enlarge it self in Claps of Thunder; which,
 involv'd in the manifold Furls of the Com-
 ing Clouds; each Crack breaking the Shell
 Inclosure, gives Fire to another of the same
 kind, till all be discharged in Order at the Con-
 clusion of their Encounter; as if the Fronts of
 Battles fir'd their small Shot upon each
 other.

And if it so chance, that any of the Cavities,
 between the Fronts of those Embodied Clouds,
 be so Enfolded within the Rest; but di-
 rectly Extended, and as it were, drawn out into
 a hollow Tube; the Train of Esberial Gun-
 powder, inclosed therein, taking Fire at the
 End, presently discharges a Thunderbolt of
 refined Matter out of the Lower; as
 if as a continued Rarefaction and Lightning
 drive it; and much swifter than a Ball of
 Cannon; passeth out of the Mouth of a Cannon;
 withal it is of so subtle and penetrative a
 nature, and well fitted to do Execution, espe-
 cially where it finds most Opposition; as some-
 times

times to melt the *Sword* and spare the *bard*.

This *First Discharge* being over, presently succeeds a *Second*; and this is back'd with *Third, Fourth, Fifth, &c.* as long as their *common Store of Ammunition* holds out to maintain the *Fight*; for the prevailing *Storm* beats back the *yielding Wind*, and still encounters the *fresh Supplies* of fiery Matter, while it beats up the *Rear*; They jointly fill the *Air* with repeated *Volley's of Shot*, till the *assailant Storm* is spent in the *Pursuit*; and the *defendant* may be so reinforced to resist by its *Retreat*; Both Sides after all are well content to acquiesce with a drawn *Battle*: The *Air's Equilibrium*, for which they engaged, being perfectly *Restored*.

§. 2.

Thus the strongest *Storms* are soonest spent, if they be not prolong'd by *Intervals*, because their *Supplies of Matter* be quite *Exhausted*, and their *intermitting Fits* grow sometimes *Chronical Distempers* of the *Air*, when scattered *Clouds* spread into *Overcasts* aloft Mountains, and become a *Boundless Ocean* of *Wind and Water*; without any other Direction than to follow the *Propension* of their own *Weight* towards their *heaviest Side*; or that which the *substrate Air* is *least able to support*: And, being once *sway'd that Way*, they are carried down the *same Declivity* thro' the *Air* ever afterwards. 1. Either according to their own *Breadth*, as at once to involve *whole Nations* in a *Tempestuous Deluge*; 2. Or only in *Part*, as

low

g the special Impulse of some Exterior Agent first set 'em on foot; and that Part being a Second; and this a Third; the Impression is carried on to the Rest properly, as long as a Train of the like Disposition continues in the Air to receive and encourage their Motion. Now, in regard Tempests commonly compos'd of Wind and Water; and flashes of Fire intermix'd; and still some of 'em is predominant above the Rest: here an Instance of every Sort.

the First Sort, whose chief Ingredient is was That horrid Tempest, which some ago, raged so dreadfully in the South of England, and drove the Sea over so much in the West, and threatned London with a great Devastation, by the Overthrow of some things, than was caused by Fire in the great Conflagration: And pass'd afterwards beyond the far as Denmark. It must needs have been kindled and encouraged all that Way, by the Windy Disposition of the superintending Spirit, which first set it on foot in Cornwall, near Land's End, to carry it forward all the while till Stock was spent, and the Hurry was over.

the Second Sort, which chiefly consists of was That prodigious Storm of Hail (or Rain) which pass'd soon after, on the 29th of May, thro' Lancashire and Yorkshire in two Days space, from the Irish Sea to the German Ocean, pouring down Stones all that way of more or less than ten Inches Circumference, and some of them ten Inches long; and of all Shapes and Sizes imaginable, to the great Wonder and Astonishment of the People.

Of the Production of WIND.

Astonishment of the Beholders : Such was the *favourable Disposition* of the Air all along for the *Storm*, as to *continue the Impression* of its first pulse, according to the *same Direction*, *Sea to Sea* ; the *Motion of the Wind*, as it was from the *One Extreme to the Other* in so short Time, being next to a *Calm*.

And as to the *watry Vapours* where the *Storm* consisted, they being driven, at their first *Concretion*, *disorderly into Unequal* by tempestuous Blasts of Wind ; And afterwards suffering a *more irregular Composition* by the *Shock of Thunder* ; concorporated in their fall into *greater and more unequal Balls of Moisture* as long as they remained *Liquid* ; but drawn after 'em a *frosty Air*, they became *Congelated* and after that, being precipitated into a lower Region below, were *Cemented together* into an *Icy Constitution* ; and became *Formed* as they grew larger, into the *Oddest Shapes* ; *Precipitation and Chance* could possibly produce no other *Effect*.

Lastly, That *stupendous Commotion* in the Air which so much damnified *Holland* that it *blew down all the Steeples in Utrecht* (that of the *Cathedral* only excepted,) and reduced the *Church* to a *Heap of Rubbish* ; and *engulfed Amsterdam* to the same Fate : As it consisted of *Vapours and Exhalations*, with the *Storms of the Two former Sorts* ; so it was *stinguish'd* from 'em by additional *Flashes of Lightning* and *Smoak* ; to express in *Thunder and Lightning* the utmost *Fury* that *Fire and Water* could exercise upon one another ; and *Both combined* upon all things else, in order to their *destruction*.

Now, to distinguish, after some manner, a storm from a Tempest, which alike proceed from a Stagnation of Vapours and Exhalations intermix'd: The Former seems at first to break out of the Sky thro' a small Cloud, as it were out of a Bottle of a narrow and contracted Orifice; it presently spreads itself to a greater Compass, and dischargeth its Fury with so great Violence and Precipitation, that it is soon over: But the Tempest slides thro' the Air with a sloping Deviation, as one Plain does off another upon the Declination; and becomes of a longer Continuance, and larger Extent: Yet Both are agreed to follow some previous Determination, to direct their Motion forwards progressively: Whereas, on the contrary, the Spout and Hurrican always begin with a Calm, and end in a Circumgyration; according to the Remarks commonly made upon them; and which are laid down at large in the ensuing Section.

SECT. V.

Of the Production of Whirlwinds, Spouts, and Hurricans.

HAVING consider'd the Motion of the Wind, as being either conducted by the Course of the Sun; or byass'd by the unequal Poise of its Gravity; or drawn aside by the Declivity of the Surface of the Ground whereon it falls: It remains to Enquire, to what Point of the Compass

Of the Production of WIND.

pass it wou'd steer its Course, in case of a pure Indifferency in all those Respects; which may happen in a Calm, upon a Plain, in a Summer's Morning.

In this Case it is to be Observ'd, that as soon as the Rising Sun begins to warm the last Evening's Dew into a Morning's Mist; if the Ground whence it is rais'd, be throughout of the same wet or dry Constitution; the Air grows by Degrees grosser and more Opacous, in the like Proportion, without any other Discomposure: But if, on the contrary, it be variously interspersed with Lakes or Boggs, to charge the Air unequally with their Effluvioms; it seems to become somewhat Uneasy, fleeting gently To and Fro, and advancing higher into a cooler Region, begins to break into the several Consistences of Vapours and Exhalations; and the more subtle and Aqueous Part still Ascends, and Rarifies into the purer Air; while the grosser and Terrestrial Matter sinks alike in it, being condensed by Refrigeration.

And withal, being contracted into a lesser Compass, those Exhalations separate into distinct Bodies; as having been diversly furnished from the adjacent Places; and being Becalm'd turn round in vain, to find out some special Direction; while their devolving Spires, by halting their Descent (Periwinkle-like) draw each into a narrower Compass; and twist themselves at last into almost so many Points: But when they reach the Bottom, they unfold themselves and spread again spirally; and Those which fall upon Water, according to their different Inclinations, draw as great a Diversity of Figures upon its Superficies, running through all the Con-

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Of the Production of WIND.

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tions: While those which fall upon *Land*,
 pick up *Leaves* and *Sticks*, Here and There,
 the *Woods*; and *Straws* and *Stubble* in the
fields; which they scatter and disperse again,
 as irregular a *Diversity* of *Curvilinear* Mo-
 tions; till the first supervening *Blast* of *Wind*
 carries off the *Scene*, and spoils their *Sport*.
 But if the *Calm* happens to continue, till
 the *Mists* be drawn up into *Clouds*; and these
 be *Evaporated*, as to their watry Part, into
 ; Each of them leaves in the *Sky* a dusky
 security of *Exhalations*, of a more inseparable
 composition, behind it; which, being more pon-
 derous than the *Common Air*, sinks a while,
 perpendicularly, down it; till the suppress'd Part
 growing more *Condens'd* below, and making a
 greater Resistance to their Descent; Those *Em-*
 pted *Exhalations* are forced to slip aside Ob-
 liquely, to find an easier Passage Downward:
 which way soever they tend, still meeting
 with more Resistance, they deflect their Cour-
 se more and more towards the Center of their
 rotations; where, the Motion being slowest,
 the Air Matter becomes most ponderous, to draw'em
 therward till they become *Circular*: And the
 leading Part of each Division, drawing down
 after it its concomitant Body of *Exhalations* (spi-
 ritous,) by the same vertiginous Tract, they be-
 come so many *Whirlwinds*; which increase their
 speed at every Turn till they reach the
 ground: And then being determin'd, either by
 the previous Declination of the *Air*, or by the
 activity of the *Earth's Superficies*, whereon they
 fall; they move forward with a progressive Cir-
 culation, ever after; just as *Straws* or *Leaves*
 fall into a *Whirlpool*, contract the same vertigi-

Of the Production of *WIND*.

nous Motion, and continue it down the Stream progressively, till they be quite Dispers'd.

Thus a *small Quantity of Moisture*, hois'd into the Sky and let fall down again, become a *Whirlwind*; but, being only the Production of one Morning's Sun, especially at Land and Our cool Climate; it wants both *Height* to Fall and *Weight of Vapours* to drive the Air into any farther Disorder: But, on the contrary, the Sea, where the Surface of the Water is throughout *Uniform* to yield an *equal Supply* of Moisture on all Sides at once; They must, upon longer Continuance, spread more evenly, like a *Canopy*, over the whole Face of Heaven; and be of too large a Compass for the said Whirlwind Motion; and for want of other Determination as an Unsupportable Load, must at last break down a Sallyport by main Force; and Tumultuously rushing into it from every side, multitudes crowd themselves into a Spout; and discharge their Stream down a Pillar of Water into the Sea; till the Tumult surceasing for want of a farther Supply, the Top of it (which before seem'd to reach the Heavens) is let fall at last and Immers'd in the Ocean.

Hence it is constantly observ'd, that, for several Days before the Spout chanceth to fall, the Surface of the Sea continues Smooth and Even, to furnish more Vapours by its uniform Reflection: Besides, the Air remains profound Calm, not to drive 'em into irregular Heaps of Clouds, and occasion their untimely Fall: Moreover, the whole Face of Heaven appears Serene and Clear, not to hinder the Motion of the Sun's Light or Heat, from raising 'em

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their full Height ; and holding 'em steady throughout their Expansion over the whole Firmament, their Burden is render'd throughout alike supportable, by the Equality of their Dispersion ; and every where Invisible ; till at last growing Ponderous, and the Sun's Beams too weak to support 'em, a Breach is made ; and, all crowded thither, they condense into a Cloud ; and hurried into a Spout by their Precipitation ; the leading Part drawing the whole Mass of Vapours after it ; till the oppress'd Air be quite burthen'd of its Load ; and that vast Expansion of Vapours, that oppress'd it, be Exhausted.

To describe the whole Appearance, according to Observation ; before the Cloud (which is infallible Prognostick of the ensuing Storm) is visible, is discern'd a dusky Obscurity in the Air, of a thin Rain, hasting from all sides towards the Center where it is to fix ; and the Sea's surface becomes plain underneath through the pressure of the Air, which designs the Compass wherein it must Fall ; which soon grows rough again, with the Disturbance that attends it ; and contracting the same whirling Motion, consisteth the preliminary Drops of the Storm, which before were thin scatter'd by their Gyration) into a thick sort of Rain, which seems to ascend out of the Waves : As a Fogg which rises on a Summer's Evening, condensing first low, seems to rise again, though the Vapours which augment it, really descend all the while ; and the said Cloud, stooping from above still lower, meets the Other which seems to rise ; and they both congregate at last into a Pillar of Wind, and a Stream of Water intermixt ; which

G 3

spreads

spreads itself more and more upon the Surface of the Ocean, *Spirally*; as long as their common Stock of *Vapours* and *Exhalations* can hold out to maintain it.

Such Defluxions or *Cataracts* of Water from the Sky, are commonly call'd *Spouts*, from their *Watry Composition*, and *Perpendicularity* for their directer *Tendence* towards the Centre of the *Earth*; while others, which are of more *Airy constitution*, are as properly name *Hurricanes*, from the *irregular Disorder* and *Fury* of their Motion; as consisting mostly (if at Land) of *hot and dry Exhalations*, and *sulphureous Steams* of Minerals; and are so impregnated with the *Beams* of the Sun, as to *ferment* and *take Fire* upon every small Agitation. Or, if they be raised at Sea, the *brackish Vapours*, that are exhaled from it, soon become *sultry Air*; which, *alike intermixt* with the *Rays*, become a *combust Matter*; and at every Turn, send forth *Lightning*; which, being involv'd in the *surrounding Clouds*, upon every Eruption, make *Claps of Thunder*; which are discharg'd, in *Peals*, one upon the back of another, after a *Furious and dreadful Manner*.

To calculate in some Measure, the unconceivable *Fury* of this raging *Meteor*, from the *Mass* of the *Matter* whereof it consists, and the *Height* whence it descends: The *Form* probably extends to a *hundred Leagues* in compass, and to a *Depth proportionable*; which, having made a *Breach through the sustaining Air*, crowds it self into that *small Cloud* call'd *Ox-Eye*, by hastning thither on all sides at once, and condensed into an unsupportable Load
forcet

receiveth its Way through that narrow Passage downwards, for a Thousand or Fifteen Hundred fathoms ; as from the Top of the Teneriff down to the Sea ; accelerating its speed all the while, perhaps to equalize that of a Flash of Gunpowder out of the Mouth of a Cannon, and be able to do the same Execution.

And descending all the while through a Medium impregnated, at so sultry a Season, with sulphurous Matter, drives it on Heaps, and involves it within its spiral Folds ; till, either compress'd by so close a Confinement, or overated by too much Agitation, it takes Fire, and dischargeth it self in Thunder and Lightning, into Clouds of Smoak : And, after it reacheth either Land or Water to obstruct its Course, fulminates at last, to break down all Opposition ; either by main Force, if it be erected on Stone, or dug out of Quarries ; or else dissolves the most solid and compact of Metals, by the minuteness of its Parts, and by Menstruums proportion'd to their specifick Natures ; according to the different Qualities of the Minerals whence they are extracted.

And, to continue the Storm, lest the Force of this fiery Meteor should abate by a greater Extension ; its unfolding Spires, by encompassing more Air, still takes in new Matter ; which serves for Fuel to increase the Flame, as long as the Ethereal Exhalations hold out to pursue its Course, and furnish it with fresh Recruits ; and the Tumult ceaseth not, till the Air's Magazine be drain'd of such sulphurous Matter, for a considerable Compass.

Conclusion.

THUS the Spout and Hurrican are rais'd alike, by the *last* and *strongest* Efforts of the Sun's Rays; the *Former* consisting chiefly of *cold* and *moist* Vapours; and the *Latter* of *hot* and *dry* Exhalations: and at Land they are commonly extracted according to their *different* Constitutions; the One, out of *dry* and *desert* Places, where Sulphur most abounds; and the Other out of *Boggs* and *Fenns*, where Moisture is predominant: And at Sea, where *Salt* and *briny* Vapours are exhaled, in the *greatest* Measure, and for the *largest* Extent; the Air remaining *Calm* all the while, to receive 'em *Evenly*; and *Undisturb'd*, not to drive 'em into *Heaps*; the Sky being throughout *Serene* and *Clear*, to leave the Sun the free Exercise of his *Heat* and *Lustre*; and withal to *Advance* and *Support* 'em at the *highest* Pitch, over the whole *Expansion* of the Firmament, as far as it is *Visible*; and this both according to *Reason* and *Observation*.

Hence it comes to pass, that off the *Coast* of *Guinea*, at *four* Degrees *North* Latitude, where there is almost a *perpetual* *Calm*, Spouts most abound; especially in *August*, when the Sun is *vertical*, and his Rays *perpendicular*, to draw up a *greater* Quantity of Water, and support it longer at its *greatest* Height: Again, at the *Caribees*, where *Islands* lye thick in the Sea to furnish an abundance of *Exhalations*, as well as *Vapours*; after the *Trade-wind* is lessened gradually into a *Calm*, the Sun raiseth the

furthest

of *Hurricanes*, consisting alike of *Air* and
; and, altho' they fall not *Periodically*,
ertain *Seasons*; yet always, when the *Calms*
more frequent than ordinary; and those
sts that usually rage on the Coast of *Coro-*
l, and the *Southerly Isles* in the *Sea of China*,
stantly fall at the End of the *Westerly*
ons, that they are commonly call'd *The*
ng up of the *Monsoons*; so that every where
n indispensably attends 'em.

And it is to be farther noted, that those three
s, tho' most obnoxious to *Spouts* and
Monsoons, yet they are seldom found in their
es; as in the *Gulph of Arabia*, where the
ons intermit not, tho' it be continued to
of *Coromondel*; nor amongst the *Antilla's*,
e there is commonly a *Southwest Wind*,
they lye next adjoining to the *Caribbee*
; nor upon the *Equator* on the aforesaid
of *Guinea*, where there blows a strong
ly *Wind* almost perpetually: so that
e there is no *Calm* there is no *Hurricane*,
l other *Dispositions* for it be what they will.
And as for those *Spouts* or *Hurricanes* that
en out of the *Tropicks*, where the *Sun's*
are less able to *Raise* and *Support* 'em at
nsiderable height in the *Air*; they most
monly *Ascend* by such heights of *Ground*, as
rominent to those *Seas*; as near the *Cape*
d *Hope*, and the *Pique of Teneriff*, that their
ours and *Exhalations* may climb up the
with more facility, having the one Foot fixt
it, than to mount properly of themselves
the *Air*; and those which at first make
east *Appearance* in the *Air*, as being *highest*
mounted,

mounted, still become by their greater Fall, most *Furions* and *Dreadful*.

Nor can it rather be imagin'd, that Force of any *Rarefaction* made in the Air displode so sudden a *Push of Wind*, as to drive a *Hurrican* into so tumultuous a *Distract* or that *Eolus* had bagg'd up those *Blas Caskets of Leather*, till, all on a sudden, broke stitches with their *Inclosure*; yet Down-fall from so great a *Precipice* does not rally occasion it: Or that a *Whirlwind* some violent *Concussion* of the Sea, hoysed so many hundred *Tuns of Water* in so small Space, to feed the *Spout*; rather than the *Triton* laves 'em out of the *Ocean*, and 'em up till their *Vessels burst*: Whereas the *Sun's Rays* draw 'em up dispers'd, till *Confluence* brings 'em down again at leisure with *Ease*: Nor that any other *Reservoir* either of *Wood* or *Stone*, besides their *Expansion* over the *Firmament* in *minute particles*, lodges 'em invisibly there, till their *Measure* be compleat: since neither *Wind* can possibly raise one discernable drop of *Rain*, the *Air* hold it stedfastly up, for one single *moment*, without letting it slip through their *gaps*.

Such is the *Affinity* of *Rain* and *Wind* in general; and their respective *Motions* are nearly related, that the *Generation* of the one mostly becomes the *Production* of the other: the same *Operation* of the *Sun's Light* and Heat commonly serving to effect 'em both; raising jointly their *Vapours* and *Exhalations* as long as the *Force* of

can hold out to support 'em : But after they are beholden to the *Declivity* of to direct their several Motions ; and to the *Concavity* of *Valleys*, to give their *Showers* and *Blasts* a different Conduct : And, as for the *several Distinctions* of *Storms* and *Tempests* (which are higher mounted,) on the One hand, and of *Spouts* and *Hurricanes*, on the other ; I have sufficiently shewn, how they are easily reduc'd to, and explicated by reference to the *unequal Byass* of their own *Gravity*, or the *uneven Yielding* of the supporting Earth. And that the *Later* contract their *whirling Motion*, purely from the *Want* of any such Determination : So that it only remains, for *Illustrations sake*, to bring the Truth of what has been already concluded of the *Accidents of Rain and Wind*, by *Reason* ; to the Test of *plain Sense* and *daily Observation*.

S E C T. VI.

Rain and Wind Accorded by the *Weather-glass*.

NOW to shut up the whole Account I have given of the Production of *Rain and Wind*, in the Two last Chapters, with One *particular Close* ; To illustrate all that I have said upon this Subject, by bringing it to the Test of our Senses and Experience, 'tis expedient to consult the *Baroscope* : which, as an *equal Balance*, by weighing the *Air* in one Pan of the Scales, against a Counterpoise of *Quicksilver*.

Quicksilver in the Other, plainly shews *Ponderation* of the *Atmosphere* at all times ; consequently how our *Theory* of the Sun's sing *Water* into *Vapours*, and *Air* into *Exhalations* ; and letting 'em fall again into *Rain* and *Wind*, corresponds with the *Rise* and *Fall* of the *Quicksilver*, as being their proper Effect.

First, We find by Experience, that at the greatest *Evacuation* of the *Air*, the *Quicksilver* stands to 27 Inches ; yet, as soon as the *Heat* of the Sun raiseth the least *Fog* or *Mist*, it presently resents it with a *Blebb* in the midst of its *Tube* ; where it has most *Liberty* to rise within it self, before it has got Strength to lose its *Adhesion* to the Sides of the *Tube* ; but when the *Heat* abates, it returns to its former *Level*, by the *Depression* of its own Weight, and sinks lower into a *Dimple*, if the *Evacuation* continue ; which serves for the *instinctive* Remarks of *Fair* or *Foul Weather* to ensue ; but a sudden *Shock* of the *Tube* restores it either Way, to the true Height of the present Season.

Secondly, When the Sun, by his repeated Beams, redoubles his Force, and adds a correspondent Quantity of *Vapours* and *Exhalations* to the *Former* ; and withal, raiseth them jointly to a higher Station ; the *Quicksilver* advances in the *Tube*, in both Respects at once in the same Proportion ; as a daily *Prognostic* of fairer Weather ; which is no sooner continued, than those *Fogs* and *Mists*, that appear'd, become *Rain* and *Wind*, by the higher *Fall* and deeper *Descent* ; which the *Quicksilver* farther resents at a correspondent Rise.

a longer Descent and greater Precipitation. Thirdly, In regard the Constitution of the Air, it is a Fluid, and the Vapours and Exhalations mixed with it is charged, Heavy and Ponderous; by consequence, the Superficies of the Atmosphere, which they compose, naturally Even Level; so as not to lye parallel to the Surface of the Earth underneath; which is solid and rugged, and still more depress'd towards the Poles. Hence it is, that the Quicksilver stands lower in the Baroscope, when 'tis nearest to the Pole; as supporting the Longest and Heaviest Column of Air, in proportion to the intensity of the Thickness of the Atmosphere: Hence we find there the sharpest Wind and the most intense Rain, as falling down a greater perpendicular.

Fourthly, Whereas it is again found by Observation, that the Quicksilver never ascends higher than 31 Inches; nor descends lower than 29 Inches, be the Situation of the Place what it will: It must have the Weight of the Atmosphere, as well as the Vapours and Exhalations, superadded Load of Vapours and Exhalations, Geometrically Stated Compared, as 4 to 27; the mean Space between 'em serving for a Scale, to measure the several Degrees of Fair and Foul Weather, as it varies by Inches; and (were the Bore of the Tube enlarg'd, and fill'd with Water instead of Quicksilver) it wou'd weigh the different Ponderosities of Air at their several Seasons, as it varies by Ounces, with the greatest Exactness.

Fifthly, In consideration that the said Vapours and Exhalations, whether they Ascend or Descend, still retain the same Weight, as consisting

sisting of a *like* Portion of Matter ; yet
rently affect the *Baroscope*, and more in
 than *Foul Weather* ; as being easier to
 any portion of Weight than to raise it ;
 again to let it fall than sustain it : Besides,
 quantity of Matter, by a repeated Division
creasing its Surface, and becoming more
 ble ; the Rays of the Sun (while those Vap
 and Exhalations retain their *invisible Size*)
 hold 'em fast : But when they begin to
 pound together, as growing too compact to
 supported any longer, and thereby *Alleviate*
 the Air, let 'em slip, and give the *Quick*
 free leave to descend.

Sixthly, Since the said Vapours and Ex
 halations retain their *invisible Size*, as long as
 are on the *rising Side* ; the Air must hold
 in *suspense* at their *greatest Height* for
 time ; and after that, let 'em sink down
 by protracted *Degrees*, till several Concre
 have considerably *alleviated* the Air : so
 the *Quicksilver* has opportunity to give
 timely notice of the ensuing Rain, several
 before it happen : And if the sultry Heat
derneath rarifie 'em again before they app
 the Earth, the Fall of the *Quicksilver* may
 vent it several Days, nay sometimes Weeks
 more ; and upon such Repetitions, the *Qu*
silver pays constant Attendance on
 Changes in the *Atmosphere*, by *Rising* and
 ling alternately all the while.

Seventhly, It is remarkable, that the
 which suffers the said *Alterations*, being
 tremely *Fluid* ; and the *Atmosphere*, whe
 they are stirred up, of a *Thickness* proportion
 to allow it, upon any Commotion, free Lib

yet it self again into the *easiest* Posture :
 in it is, that the *Prognosticks* of different
 o *er*, commonly extend farther than where
 it ; *change* is actually made ; as when the
 des, *ther-glass* in *Lancashire*resents the Fall of
 rision in *Yorkshire* : And sometimes the Aerial
 ore *ations* are vastly extended, that discharge
 Vap *Burthens* within a *small* Compass, as
 Size) *ns* in *Spouts* and *Hurricanes* ; and some-
 a to quite contrary, as in the Burning of
 act t ; which rais'd the *Quicksilver* both at
 llevia and in *Lancashire*, higher than it has been
 quick'd in either Place ever since.

ably, In case the *Baroscope* falls lower
 and E the *Temper* of the *Weather* seems to re-
 g as by my present Account it is occasion'd
 hold e *Wind* ; which tossing the *Clouds* to and
 or f alleviates the *Atmosphere* by their *Agita-*
 wnn Besides, the *Wind* blowing *Horizontally*,
 acree needs divert their propension downwards
 so n way ; and the *Higher* the *Wind* riseth,
 give over the *Quicksilver* falls ; and when the
 ral H is quite fall'n, it must return to its former
 Heat : Hence it follows, that it must stand
 ppro ft in the longest *Drought* and calmest *Wea-*
 may and fall Lowest in the *Depth* of a *Rainy*
 Week stormy Season, when the common *Stock*
 e Q vapours and *Exhalations* is Exhausted.

on ly, Seeing the *Quicksilver* stands no
 and r in *Summer*, when the *Weather* is *Hottest*,
 the said *Vapours* and *Exhalations* most
 the d ; than it does in *Winter*, when the *Air*
 eing ost intensely *Cold* and *Dry* ; and has not
 whe Mass of *Rainy* and *Windy* Matter to be
 ction'd, nor the *Sun* to support it : Hence I
 Lib needs infer, that the *Atmosphere's* *Gravi-*
 tation

tation grows more propense for want of reverberated Rays to alleviate it by Rebo and draws its Summer's and Winter's Position towards an Equality: But upon a farther Consideration, that tho' it be Composed of the grossest Air, 'tis thoroughly Rarified by Summer's Heat, and alleviated by the Horizontal Motion of the Wind; and Condensed again by the Winter's Cold, to its natural Gravity to restore it to the proper Exercise of its Circulation: Which cannot fail to adjust its Summer's and Winter's Pressure upon the Barometer to a perfect Equivalence at both those Seasons.

So exactly does the Rise of the Quick-silver in the Baroscope describe the Weight and Counterpoise of Vapours and Exhalations, raised up in the Air by the Beams of the Sun; and when Ponderation sinks 'em down again into Springs, Rain, and Wind, with a Dependence upon the endless variety of contingent Circumstances within the temperate Zones: Whence it is that we are to discuss, how, on the Contrary, the direct Conduct of the Sun's Course alone prevails in the Torrid; to fix the said Variety into so fast and Settled an Influence upon the Motion of the Wind, both as to Force and Point, as to render 'em either Periodical or Perpetual.

CHAP. IV.

Of the Motion of the WIND, as depending on the Course of the SUN.

SINCE the Heat of the Sun, both *Raiseth* and *Supporteth* the Air, inas-
much as it is the subject Matter of the *Wind*; and solely disposeth it to *descend* again, meerly by the composition of his *lighter* Rays with the *beaver* Air, *puffing* it up *Spherically*, and letting it alternately by *Condensation*, when they are *withdrawn*, as it were, to fill up the *Vacuity* behind 'em: And, in regard the *Sun* at once both *Enlightens* and *Warms* one *Hemisphere* of the *Globe*, and turns around it in *Twenty* *four* *Hours*; it must, *Cæteris paribus*, draw the *Air* and after it by the *same* Means and the *same* way, in *all* Places *successively*, from Pole to Pole; in compliance with its *Westerly* Motion. But not at the *same* Rate; running a *Thousand* *Miles* an *Hour* upon the *Equator*, with respect to the *Earth's* *Superficies*; which, at the *Poles*, are shut up in a *Point*; from whence increasing his Speed, pariform to the *different* *lengths* of the *intermediate* *Parallels*; and the *longer* his *Course* grows, moving the *Air* more and more effectually; the *Wind*, adding to his *Diurnal* *Course*, upon its *Advance* to about *Thirty* *Degrees* of either *Latitude*,

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tude, blows to the *Westward* perpetually ; especially *at Sea* ; where no Land-Impediments fall in its Way, either to obstruct or divert it.

And although, pursuant to his Diurnal Course from *East* to *West*, (which is so *Swift* and *Direct* between the *Tropicks*) the *Wind* moves *constantly* towards the same Quarter yet still with due regard to his *Annual Declination*, it deflects more *Northerly* or *Southerly*, according to the *different* Seasons of the Year without a Dependence on any other Cause inasmuch as its Blasts *soar aloft* in the Air where its Flux is most *Uniform*, and easily inclined to follow those *solar Impressions* ; but, in regard its *natural Tendence* declines it towards the Center of the Earth, and it falls at last upon the Surface, either of *Sea* or *Land* ; it must in some Measure, be *Regulated* by the Conduct of their *Situations* ; especially *Land*, where its Surface is *rough* to hinder its Speed, or *oblique* to deflect its Course.

Again, notwithstanding the *Water's* Superficies be *smooth* for the *Wind* to glide easily over it ; and of its own Nature *preponderate* the incumbent Air, which is much *lighter* and consequently apt to *float* upon it, without *ruffling* its Plain into any Disorder ; yet, in regard they are both *Liquid Bodies*, to cleave close together, and are withal effectually *applied* to each other, by the superincumbent *Atmosphere* ; the superjected *Wind* and the substrate *Sea*, must *mutually* stir up each other's Motions ; the Former by its *Weight*, and the Latter by its *Volubility*, where it has room to *rowl* ; and by consequence, the *Flux* of the

must share with the Rays of the Sun, in their sway over the Wind between the Tropicks, and very Effectually too; when the Space of their Cohesion is of a large Extent; and their joint Motion is Constant and Perpetual.

Hence it is effected, that the same Wind which was First carried Westerly, by the Diurnal Course of the Sun; and now Secondly, is declined, by his Annual Motion, more North and South; Thirdly, Is often deflected more obliquely by the Inclination of the Shores; and Fourthly, Is return'd back again Periodically, from near the Opposite Points, by the Sea's Situation; which is finally, (by the concurrence of its Flux underneath) carried perpetually quite contrary to the Diurnal Course of the Sun (which I set it on Foot,) even upon the Equator itself, for Five Hundred Leagues together.

Now the Flux of the Ocean, sharing with the Motion of the Sun, in his Conduct of the Trade-Winds in general within the Tropicks; and both being alike concern'd in the Management of the Trade-Wind in particular; it falls very opportunely to shew, what respect that Wind bears to their joint Direction in several Seas, at what Seasons, and on all Occasions; for an easy and expedient Transition from my past Discourse of the Course of the Wind, to my ensuing Treatise of the Motion of the Sea; by a suitable Mixture of Both in One, in this Chapter; before I venture upon those which are peculiar to the Ocean it self; as that of the Trade is, which depends upon quite different causes: Here I shall endeavour to demonstrate, how much the Trade-Wind is beholden to the

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Motion of the *Sea* ; and *there*, in what respects the *Sea's* Motion depends on the *Wind* ; producing all along *some Instances* for that purpose in their proper Places.

S E C T. I.

Of the Motion of the Trade-Wind, and its dependence on the Course of the Sun.

WHEREAS all this while, I have train'd up the *Wind* thro' its *Minor* from its first Production, without the *Tropicks* ; where it began *low*, and rose by *Degrees*, and generally was of a *small Extent* and consequently *easily deflected* out of its Course, by every *Bogg* and *Mole Hill* that stood in its way ; yet afforded *more Matter* than the *Slow* and scatter'd *Obliquity* of the *Sun's Rays* were able to manage : Now, on the contrary, in the *Torrid Climate* of the *World*, where his Motion is *Swifter*, and his *Rays Perpendicular* and more *Compact* ; and the *Sunburnt Earth* neither overloads 'em with *Moisture*, nor any inequality of the *Sea* makes *Resistance* to their Operation ; his Conduct of the *Wind* must be *Constant* and *Universal* ; tending *Diurnally* into the *West*, and *Annually* towards the *North* and *South* ; and its Motion must be pursuant thereto, as long as the *obscuring Coasts* and *Shores* will permit the *Air* to move the same way, without any *Deflection* or *Impediment* of some other Kind.

To begin with the general *Trade-Wind*, which is most constant for Motion, and of greatest extent : Dr. *Edmund Halley* demonstrates, that it necessarily depends on the *Diurnal Course* of the Sun ; in regard the Air, which is less rarified by his Heat, and consequently more Ponderous, must have Motion towards those Parts, which are more Rarified and less Ponderous (according to *Statics*,) to bring it to an *Equilibrium* : Again, the Presence of the Sun continually shifting to the *Westward* ; that part, to which the Air tends by reason of the Rarification made by his greatest *Meridian Heat*, goes with him, carried *Westward* ; and consequently, the Tendency of the whole Body of the lower Air is that way : Hence is formed the general *Easterly Wind* ; which being impress'd on all the Air of a vast Ocean, the Parts influence one the other ; and so keep moving, till the next Return of the Sun ; whereby so much of the Motion as was lost is again restor'd ; and thus the *Easterly Wind* is made perpetual. From the same Principles, Dr. *Halley* tells us it follows, that this *Easterly Wind* shou'd, on the North Side of the Equator, be to the Northward of the East ; and, in the South Latitude, to the Southward thereof ; while the Air is upon or near the Line : the Air being there more rarified and his Motion swifter, than any distance from it : Which Motions, by his Account, being superadded to the former *Easterly Wind*, answers all the Phenomena of the general *Trade Wind*.

Such is the *Easterly Tendency* of the general *Trade Wind* ; as also its North and South-*Easterly*

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Inclination, on each side towards the Line; while the Sun's *Diurnal* Motion keeps near the *Equator*, as Dr. *Halley* has already demonstrated: But, before I proceed to meddle with its *shifting* Motion, as caused by the Sun's *Annual* Declination towards the *Poles*; 'tis farther requisite to take along with me his *Historical Relation* of Matter of Fact, which I strictly observe, and is as follows: *Viz.*

In the *Indian Ocean*, the Winds are partly general, as in the *Ethiopick Ocean*; partly *Periodical*: That is, *Half the Year* they blow one Way, and the other *Half* near upon the opposite Points; and these Points and Times of Shifting are *different*, in different parts of the *Ocean*: The *limits* of each Tract of Sea, subject to the same Change or *Monsoon*, are certainly very hard to determine: But the Diligence [*says He*] I have us'd to be rightly inform'd, and the Care I have taken therein has, in a great Measure, surmounted that Difficulty; and I am persuaded, that the following Particulars may be rely'd on.

1. That between the *Latitudes* of 10 Degrees and 30 Degrees *South*, between *Madagascar* and *Hollandia Nova*, the general Trade Wind, about *South East* and by *East*, is found to blow all the Year long, to all Intents and Purposes, after the same Manner, as in the same *Latitudes* in the *Ethiopick Sea*.

2. That the aforesaid *South-East Winds* extend to within 2 Degrees of the *Equator*, during the Months of *June*, *July*, *August*, &c. to *November*; at which time, between the *South Latitudes* of *Three* and *Ten* Degrees, be-

g near the Meridian of the *North End* of *Madagascar*, and between *Two* and *Twelve* *South Latitude*, being near *Sumatra* and *Java*, the contrary Winds from the *North West*, or between the *North* and *West*, set in and Blow for half a Year ; viz. from the Beginning of *December* till *May* ; and this *Monsoon* is observ'd as far as the *Molucca Isles*.

3. That to the *Northward* of *Three Degrees South Latitude*, over the whole *Arabian* or *Indian* Sea, and *Gulph of Bengal*, from *Sumatra* to the Coast of *Africa*, there is another *Monsoon*, blowing from *October* to *April*, upon the *North-East* Points : But in the other *Half* Year, from *April* to *October*, upon the opposite Points of *South West* and *West South West*, and that with rather more Force than the Other, accompanied with dark *Rainy Weather* ; whereas, the *North-East* blows clear : 'Tis likewise to be Noted, that the Winds are not so constant, either in Strength or Point, in the *Gulph of Bengal*, as they are in the *Indian Sea*, where a *Certain* and *steady Gale* scarce ever fails : 'Tis also remarkable, that the *South West Winds* in those Seas are generally more southerly on the *African Side*, more *Westerly* on the *Indian*.

4. That, as an Appendix to the last describ'd *Monsoon*, there is a Tract of Sea to the *Southward* of the *Equator*, subject to the same Changes of the Winds ; viz. Near the *African* Coast, between it and the *Island of Madagascar*, or *St. Lawrence*, and from thence *Northward* as far as the *Line* ; wherein, from *April* to *October*, there is found a constant fresh *S. S. Wind* ; which, as you go more *Northward*,

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becomes still more and more *Westerly* ; so as to fall in with the *W. S. W. Winds*, mentioned before in those *Months* of the Year, to be certain to the *Northward* of the *Equator*.

5. What *Winds* blow in these Seas for the other *Half Year*, from *October* to *April*, [He had not yet been able to obtain to his full Satisfaction ; for that our *Navigators* always return from *India* without *Madagascar*, and are little acquainted in this Matter : The Account that has been given [Him] is only this that the *Winds* are more *Easterly* hereabouts and as often to the *North* of the true *East* as to the *Southward* thereof.

S E C T. II.

Of the Shifting Trade-Winds ; and their dependence on the Sun's Zodiacal Declination, with regard to the Equinoctial Position of the Arabian Sea.

SO strictly does the mutual Concourse of the *North* and *South-Easterly Trade-Winds* observe the *Equator*, while the *Sun's Diurnal Motion* keeps close to that Line : But, when his *Annual Declination* withdraws his *vertical Rays*, and the *Air* grows cooler in his Absence ; the joint Occurrence of the said *Winds* (as following close to his greatest *Meridional Heat*, must also decline with him into the same *Latitude* ; whether it be to the *North* or *South* : And those *Winds* must make their *half Yearly Returns*

; so as the Winds of *Summer* and *Winter* alternately, on
side of the *Equator*.

besides, the said Space of rarefied Air, still
ling the Sun's *Zodiacal Declination* suc-
ely towards each of the *Tropicks*; and
intermediating between the said *North* and
Easterly Winds, must needs stagnate into
of so considerable a Breadth, on each
that *shifting Line* describ'd by the Sun's
tion, as to hinder the said *opposite Fluxes*
from approaching each other at their
crossings; that Geographers commonly assign
Tract of *twelve Degrees* Tranquility: So
the Sun's *Tropical Declination* (being ex-
d at least *twenty-three Degrees*,) more than
y sufficeth, to draw the said *Vacuity* from
side of the Line to the other, with an
early Vicissitude; as is Manifest.

Now, the Position of the *Arabian Gulph*, or
part of the *Indian Sea* which the said *shift-*
North and *South-Easterly Winds* chiefly affect,
Equinoctial; it concurs very opportune-
with the *Zodiacal Motion* of the Sun, ei-
to remove 'em Alternately out of that
pass, as not exceeding *ten Degrees* on the
of the *Equator*, and *twelve Degrees* to the
ard of that Line; or at least, to abate
Force in such measure, as not to be able
ist the *South*, and *North-westerly Monsoons*;
n of course succeed 'em from the Opposite
ts every *Half-Year*, at their respective
ns, to supply the *Vacuties* left behind

ence it comes to pass, that the *North* and
East Trade-Winds, never blow Both at
within the Compass of the Gulph or Sea
aforesaid;

aforesaid; the *One* being no sooner drawn by the Sun's Declination, than the *Other* is brought on again by its own Weight, to the *Vacuity*, left on the other Side of the *Equator*: For so it happens in *April*, when the *South* having pass'd the Line into the *Northern* Hemisphere, at once carries off the *North-East* Trade-Wind from it, and draws Thither the *South* Wind after it; and having repass'd it again to the *Southward*, brings those Winds back again, and so carries 'em *Backward* and *Forward* alternately, the *One* towards the Line, and the *Other* from it, by an *Half-Yearly* Vicissitude for ever.

It is farther observable, that those *East* Trade-Winds, and *Westerly* Monsoons, which happen at the *same* Time, blow jointly either towards the *North* or *South*: As from *April* to *October* Both blow to the *Norward*, pursue the Sun's Declination into the *North*, drawing 'em Thitherward, from a more dense and Ponderous *Winterly* Season, into a more expanded and rarefied Air of *Summer*; on the contrary, They jointly, from *October* to *April*, attend in the *South* on his Presence upon the *same* Occasion; so that the *Westerly* Monsoons, inasmuch as they blow *Northward* or *Southward*, are as effectually Influenced by the *annual* Course of the Sun, as the *Easterly* Trade-Winds are to blow Hither or Thither at the *same* Season.

Hence it comes again to pass, that the *South-Easterly* Winds, as Dr. Halley observes, tend from the aforesaid *Ten Degrees South* Latitude, near the *Equator*, during the Months of *June*, *July*, &c. to *November*; while the *North* remains to the *Norward* of the Line to

hitherwards : And, on the contrary, there is blowing a *North-Easterly* Wind for the former Half-Year from *November* to *June*, when being on that Side of the *Line* to attend. Now *Why*, or *How* those Two *East-Winds*, so intermixing, shou'd each be directed for its respective *Half-Year* by a *West-Monsoon* from the Opposite Point ; and to be a Cause able to produce so constant an Effect, leaves no *Phenomena* of the *shifting Winds* Unaccounted for.

S E C T. III.

Of the South and North-western Monsoons, respectively Regulated by the Situation and Nature of the Arabian-Sea.

HAVING shewn already (in the Former Part of the Two precedent Sections,) that the *North-Easterly* Wind, which blows perpetually from *Thirty* to *Ten* Degrees of the same Latitude, is drawn *Eight* Degrees nearer the Equator on the *East* Side of the *Arabian-Bay*, from *November* till *April*, by the Sun's Declination to the Norward : And in the Latter, that the *South-West Monsoon*, by virtue of his said Situation, blows to the Norward at the same Latitude. Let us see how it acquires a *Westerly* Direction, by the Conduct of the said Bay's Situation on that Side. And it is Observable,

First,

First, That the *African* Shores, which the *Ocean* towards the *West*, tend *North-E* from the *Cape of Good Hope* all along the *Equator*, and beyond it to the Bottom of the said *Bay*; the Land being *High* for the part. And *Sea-Winds*, being a *heavy* Motion must consequently as strictly observe the direction, as *Rivers* do the *Banks* which contain 'em; and the *Winds* must follow their Course as far as they reach, especially at that Season when a ponderous Load of *Winterly Air*, or *Foul Weather*, drives 'em Thitherward; with more vehemency, as *Dr. Halley* takes notice than any other *Winds* that *Trade* in the *Seas*.

Besides, the said *South Ocean*, whose Surface sustains that *South-West* Wind all the while, sending its *Tide* directly *Norward* towards the said *Bay*, being alike contracted on That Side by the *Inclining Shore*, the *Flux* of the *Coasting Current* must be proportionably hastened and consequently communicate to the superincumbent *South-Westerly Monsoon*, a more fixed steady Determination, and drive its *Flux* deep into the *Bay* as it went before.

In consequence whereto it is Observ'd, that a constant Current of the *Sea*, for all the Tract from *Madagascar* to the *Equator*, enters the *South-West* Corner of the *Indian Ocean* (where the *Monsoons* first begin to shift) carries the superincumbent *Air* along with it down into the *Arabian Gulph*: And, as *Halley* affirms, a constant fresh *South-West* Wind blowing along that Coast, on both Sides of the *Line*; which, the farther you go *North*

owing more *Westerly*, falls in (*says He*) the *South-Westerly Monsoon*; or rather, gives beginning by falling in with it in *April*, ending with it in *October*: which plainly sheweth, that They *compose* and become, there, the *same* undiscontinued Flood of Wind and Water, conjoin'd, without any division; while the Sun's *Norward Declination*, encourages the *South-West* Wind to advance, and withdraws that *North-Easterly* Wind, which otherwise would Oppose it.

When it comes to pass, that the *South-West* Wind, as being deriv'd from the joint Current of Wind and Water aforesaid; following the *South-Westerly* Direction of the *African* Coast, which still contracts and enforceth it, passes by Land and Sea; and having pass'd the proper Limit, penetrates to the Mouth of the *Arabian Bay*: Whereas, the *East Trade-Wind*, which blows at the same Time, on the *South* Side of the Line, never meets it, for want of the like Assistance from any *Shore* or *Current*, to help it forward: On the contrary, falls short of its Natural Course, at least *two* or *three* Degrees, as repuls'd by the *contrary Motion* of Sea and Wind; as will appear.

Now to derive the *North-West Monsoon* regularly from the same Source, or Current of Wind, only *reflex'd*, which brought the other regularly directly from the *South-West*; it is to be noted, that the *Bay*, wherein they are Both conjoined, is of a *Triangular Figure*; the Subjacent of whose *North Angle*, pointing directly *North* and *West*, separates the said Bay, on the *South*,

South, from the wide Ocean, with a compos'd of *Isles* and *Shallows* ; where the said *South-Westerly* Current falling obliquely, and entering into the Gulph at its *South* Angle, is reflected from near the Center of, towards the other End of the said Bay, where the Stream refunds it again, by a *Westerly* Outward-bound Passage, into the Ocean whence it came ; drawing the incumbent *North-West Monsoon* after it from *October* to its proper Season.

Conformably to the Scheme of the *Westerly Flux*, and *North-Westerly Reflux* of the said Current ; Dr. *Halley* assures us that a *Westerly* Wind attends it down the Bay ; the farther you go *Northerly* still blows *Westerly*, till they Both approach near the *stern* Shore ; where the Current (being turned on its Return towards the Ocean) reverses its Course to the *Norward*, and thence *Westerly*, till it meets in with the Conduct of the opposite *Eastern* Coast ; and follows its Direction as far as the *Maldiva Islands* ; which, tending Linearly to the same Point, steers on its Course for about *ten Degrees* farther, till it reach the *Equator*.

Now, in regard as the said Current descending into the Bay, goes on dispersing the Stream into almost Calm Water ; so the incumbent *Eastern* Shore recollects it again, and revives its Motion by the like Degrees, till it have pass'd the said *Islands* up to the *North*, where it falls in exactly with the Tendency of the *North-West Monsoon* : Hence it must stir up There a Motion in the incumbent *Trade-Wind* of That Tendency ; the opposite *South* *Trade-Wind* being already withdrawn by

Trade-Winds and Monsoons. III

Declination; and must carry that *Monsoon*,
 and, along with it, according to the *same*
on, *ten* Degrees farther, being its proper
 till it meet with the said Wind to stop
 and the Stream underneath, having pass'd
 the aforesaid Barrier of *Isles* and *Shoals*, be
 ed into the Ocean whence it came.

As both the *Westerly Monsoons* are equally
 en to the same Current: That from the
 ward, as being carried down the *Arabian-*
 wards the *North-East*, by its *direct* Course;
 this from the *Norward*, as return'd back
 by its *Reflux* into the *South-East*, in com-
 with the Streams underneath; yet
 this Difference, that whereas the Course
 Water, meeting no opposite Stream to
 its Passage, is *perpetual*: On the con-
 the concomitant Fluxes of the *Westerly*
Winds, upon the Occourse of the opposing
Winds, alternately desist, and become
cal: Those *Easterly-Winds* within their
 as, over-powering all Opposition, so
 to restrain the said contrary *Monsoons*,
 'em at liberty; while the Sun's *South*
Declination, by *half-Yearly* Returns, al-
 ly sets on the said *Easterly* Winds, or
 em off again.

Since it is, that the said *South-West Mon-*
 begins to blow in *April*, when the Sun's
 ce into *North* Signs withdraws the op-
North-East Trade-Wind, which disconti-
 all *October*; when the Sun, by repassing
 e into *South Latitude*, brings it on again:
 the *North-West Monsoon* blows the other
 ar from *October* till *April*, and then de-
 with regard to the *South-East Trade-Wind*,
 which

rifeth to countermand it : Just as *Land-Breezes* which, following the Streams of fresh Rivers, be naturally *Perpetual* ; nevertheless they are driven back *Periodically*, by the *Salt-Floods* ; their *Ebbs* give 'em leave to return again, and blow *Sea-ward* as they did before.

Again, from *October* to *April*, notwithstanding the *North-East Trade-Wind* has driven the opposite *South-West Monsoon*, from its direction to the *direct Course* of the *South-East Current*, which produc'd it ; yet its *Strength* being *reflex'd*, and still retaining its former Force and Speed, must gradually decline the Motion of the Incumbent Air from the *Eastward* to the *Westward* of the *North* all the while ; till it has repass'd the *Line* to the *Southward*, and effectually rais'd the *North-West Monsoon* ; having escaped out of the *Course* of the *North-East Wind*, which would have deflected its *Course* ; the *South-East Wind* is also withdrawn by the Sun's *Southerly Declination*, which otherwise wou'd have oppos'd and baffl'd it into a *Calm*.

Hence I conclude, That those *North-East South-Easterly Winds* which follow the *direct Course* of the Sun, never blow on both sides of the *Equator* at once ; and that that *Course* of the Sea, to which I ascribe the common *South and North-Westerly Monsoons*, serves to determine the Motion of the Air that is to supply their respective *Vacuities* till their Return : And that those *Two shifting Winds* which blow at once, tend jointly either to the *North* or *South* ; and still towards the *Equator* ; that the Inequality of their *Summer's Length*

Winter's Gravity, may give Force and
 Velocity to their Motion, so as, in Substance,
 be the same North and South Winds, but
 differently determin'd on each Side of the
 Equator; Easterly by the Sun's Diurnal Rendance;
 Westerly by the Current aforesaid.

S E C T. IV.

Of the said Shifting Winds are propagated in the
 Gulph of Bengal, and Sea of China.

NOW, for as much as the Gulph of Ben-
 gal, and Sea of China are alike affected
 by the said Western Monsoon, and at the same
 time; and all Three lye collaterally to each
 other, and lineally to the same Ocean, which
 produc'd the aforesaid Current; the Tidal Tu-
 rent thereof, to render the Cause coextensive
 in its Effect, must spread it self comprehen-
 sively over 'em All at once, to produce so general
 a Uniform a Commotion in the Air. And
 that Monsoon be not so constant, in Strength,
 Point, in the Gulph of Bengal, as it is in the
 Arabian Bay, 'tis because the Ocean, being
 contracted all along the African Shore, more
 immediately, and consequently more sharply,
 affects it; and so must needs give the Wind a
 more fix'd and steady Determination there, than
 it is dilated by a greater Expansion.

Beside, the said Gulph being alike of a
 Angular Figure, as well as the Arabian Bay;
 They lying respectively in the same Hori-
 zontal

zontal Position ; the *Tidal* Motion of the Sea, which, jointly with the aforesaid Current, falls into 'em Both with the same Obliquity, must equally affect 'em *directly* with a *South-Westerly Monsoon*, and *Reflexedly* with a *North-Westerly* One : And Both lying conjoyn'd together, open towards the *South*, and *alike subtended* by the *Barrier* aforesaid, on that Side ; the *North-West Monsoon*, as being jointly directed by both, must reach coextensively along with the *South*, from the *Eastward* of *Madagascar* to *Sumatra*, as is found by *Observation*.

But as to the *Chinese Sea*, altho' it lies on the same Side of the *Line*, and according to the same *South-West* Direction, with open Mouth towards the *Indian Ocean*, to partake of the said *South-West Monsoon* ; yet its Channel is more respecting the *North* and *South* Position, than the *Bays* aforesaid do ; its *Flux* of Air, as well as of *Water*, must needs deflect in the same way : But, it being withal an *Oblong* Tract of *Water*, and not *Triangular* ; being a *Thorow-fare* Passage out of one Bay into another, it can by no means reflect the *Stream*, either of *Air* or *Water*, back towards the *South-East* in favour of a *North-West Monsoon* ; which is neither found in this Sea, nor can be reasonably expected in any other, of a different *Position* or *Figure* from the *Bay of Bengal* aforesaid.

Now, from what I have already said of this Matter, it appears 1. That the Place so affected with the *Monsoons* must lye upon the *Equator* or near it, to shift 'em with the *Sun's Declination*, both *Northward* and *Southward*, according

the different *Seasons* of the Year : Hence all
as, of any other *Position*, are incapable of
like Alteration.

Besides, the *Figure* of that Part of the *Indi-*
Ocean which is so affected, must be *Trian-*
lar ; with an *Inlet* at its *South-West* Angle to
receive the Stream of Water which conducts
the *South-West Monsoon* into the Bay ; and an
Inlet at its *South-East* Corner, to set the
South-West Monsoon off again by the *opposite*
Point ; as appears by the special Service of
every Part of the said Bay ; and how proper
it is to perform its Office.

It was farther requisite, that a *Barrier*, consist-
ing of *Isles* and *Shoals*, shou'd pass between the
South-West and *South-East* Passages, to streng-
then the aforesaid Current (which almost
signates in the Middle of the Gulph) into a
Stream, to stir up the Incumbent Air into a
South-West Monsoon ; and withal, it was to be
of a proportionable Breadth, to continue its
flux over that Rampire for *Six Degrees* together,
to the *Southerly Ocean*, to meet the *South-East*
Trade Wind, which was to stop it before it
was'd.

And this *Barrier* was to be but of a *Mean*
Nature ; neither so *High* as to hinder the Tide
from passing over it ; inasmuch as it might be
favourable to both the *South* and *North-West*
Monsoons ; by letting the One enter the Bay as
easily at the *West* End of it, as the other to
pass off at the *East* ; nor yet so *low* as to admit
Floods in so full a manner, as to controul
or obstruct their shifting Motion.

Moreover, the *South-Western* Current of Wind,
which Coasteth the *African* Shore, from near

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the ~~Ile~~ of *Madagascar* to the *Equator* ; To which *Dr. Halley* allows a Periodical Flux from *April* to *October* ; yet terms it, not improperly only *An Appendix* of the *South-West Monsoon*, tho' it hath pass'd the *Line*, tho' it be the *Origin* and sole *Cause* thereof ; in regard, till it hath pass'd the *Equator*, it remains out of the *Sun's* Power to give it Check, and Return it when it came by his *Southerly* Declination : Especially, the concomitant *South-West Current* of the *Sea*, perpetually resisting its Trading back again by the same Road for the other Half-Year to wit, from *October* to *April* ; or at least with any Periodical Constancy or certainty of Motion

S E C T. V.

Concerning those Winds, which are Adverse to the general Easterly Winds, and are Perpetual.

TO omit Those that blow all the Year without any considerable Variation unless what is subject to be deflected therefrom some few Points of the Compass, towards the *North* or *South*, according to the Position of the Place ; as being, in all Respects, well accounted for by *Dr. Halley* already ; I shall only of course take farther notice of Those, which He proposeth for *Exceptions* to that general Rule ; in order to reconcile 'em to the Common Laws of Motion.

1. That to the *Normard* of the *Line*, between *Four* and *Ten Degrees* of *Latitude*, and between

Meridians of *Cape Verde*, and the *Eastermost* *Islands* that bear that Name, *Dr. Halley* tells us, there is a Tract of Sea, wherein it were improper to say there is any *Trade-Wind*, or yet variable; — the little Winds that are, be only the sudden uncertain Gusts of very little continuance, and less Extent; — which He refers to the Station which that Tract holds between Two contrary Winds; the One on the North-side, blowing *Easterly* from the said *Islands* towards *Guiana* in *America*; and the other on the South, from *Brazil* towards *Guinea* in *Africa*; which were more proper to turn the adjacent Air into a *Whirlwind* than to hold steady; Did not that part of the Ocean, where the *Atlantick* and *Ethiopic* Floods meet, concur to keep it fix'd, as being obnoxious neither to *Flux* nor *Reflux* to disturb its Quiet.

2. That in the Tract of Sea, which (on the South) lies next adjoining to this, the *Northerly* and *South-West* Winds are perpetual; 3. all along the Coast of *Guinea* for above one Hundred Leagues together, from *Sierra Leone* to the Isle of *St. Thomas*: For the *South-East* Trade-Wind, upon its Entrance into the Trench, (in compliance with the *South-Westerly* Tendency of the Sea-Current along the *Brazilian* Shore,) becomes *South South-East*, and by degrees full *South*: And, being carried down with the Stream towards the *Guinean* Shore, turns about to *South South-West*, and by degrees to *South-West* and *West South-West*, under the same Conduct both of that Stream and Coast; till at last the Current of Water, being repuls'd by the *Eastern* Shore of *Guinea*, returns towards the *South* (whence it came) to make Restitu-

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tion : And, being ingulph'd by the *Tide's* tumescency, is carried off by *Libration* thither, and deflects the superincumbent *Current* Air into the *South* after all, to compleat *Circulation*, as will be farther declared hereafter.

To these which *Dr. Halley* alledges, may be subjoin'd, as remarkable *Instances* of the same Truth,

1. That all along the *Western Coast* of *Peru* for above *Fifteen Hundred Leagues* together from near the *Magellanick Streight* as far as the *Gulph of Panama*, an uninterrupted and most perpetual *Flux* of Air attends the *Current* of Water which supports it ; blowing from *South* to *North* ; or within a *Point* or two to the *Westward*, according to the different *Inclination* of the *Shore* : notwithstanding the *Exhalations* which compose it fall down from the *Andes* out of the *East* ; and the *Western Indian* Ocean lies wide open to receive 'em ; without giving even a beginning to an *Easterly Trade-Wind*, for all that length of *Shore* (about *Fifty Leagues* off at *Sea*,) which is perceptible.

2. That a perpetual *Flux* of Air or Water adheres to the *Coasting Current* of the *African* *Shore* on the *Ethiopick Side*, from the *Cape of Good Hope* to near the most *Southerly Part* of *Guinea* ; which is constantly determin'd to blow *Southerly*, by the *Draught* of the *Stream* underneath ; and withal, the *Wind* keeps that *Flux* of Water on foot, by its constant descent from the adjacent *Shore*, so as Both to tend thitherward all the while, by the mutual assistance

each other ; with many *Instances* of the kind, which will be produc'd more conveniently hereafter, where I professedly treat the *Motion* of the *Sea* ; and shew, that the aforesaid *Coasting Currents* of the *Ocean* proceed from the *Tide*.

Such is the *Adhesion* of the *Incumbent Air*, to the substrate *Water*, when they are got into *Union*, and have free liberty to follow the *Direction* ; for otherwise each may be put a Stop apart, or both be deflected several ways ; as the *South-West Monsoon*, which we saw of before, while the *South-East Wind* withdrawn, pass'd along the *Coast* of *India* down into the *Arabian Gulph*, jointly with the *Stream* that conducted it : And, even if the *Current* had stagnated in the middle of the *Bay*, as soon as it reviv'd its *Motion* towards the *South-East*, still pursu'd its *reflex'd* direction : Yet, no sooner had the *South-Westerly Wind* put a *Stop* to its *Career*, and the *Current*, reflected towards the *North-West*, began to revive and gather *Strength*, but the *North-West Monsoon* did so too, and fell in with it ; attended it thro' the *South-Easterly Passage* into the wide *Ocean*, where both ceas'd together.

By this Means, these *Sea-faring Winds* take liberty to disorder those which *Trade* out to the *East*, by the *Influence* of the *Sun* ; in the *Seas* stirring 'em up too soon, and accelerating 'em above their usual speed, as near the *Line Verde* : Or contracting 'em some *Degrees* within their common *Limit* ; and by and by enlarging 'em as far beyond it ; as all along the

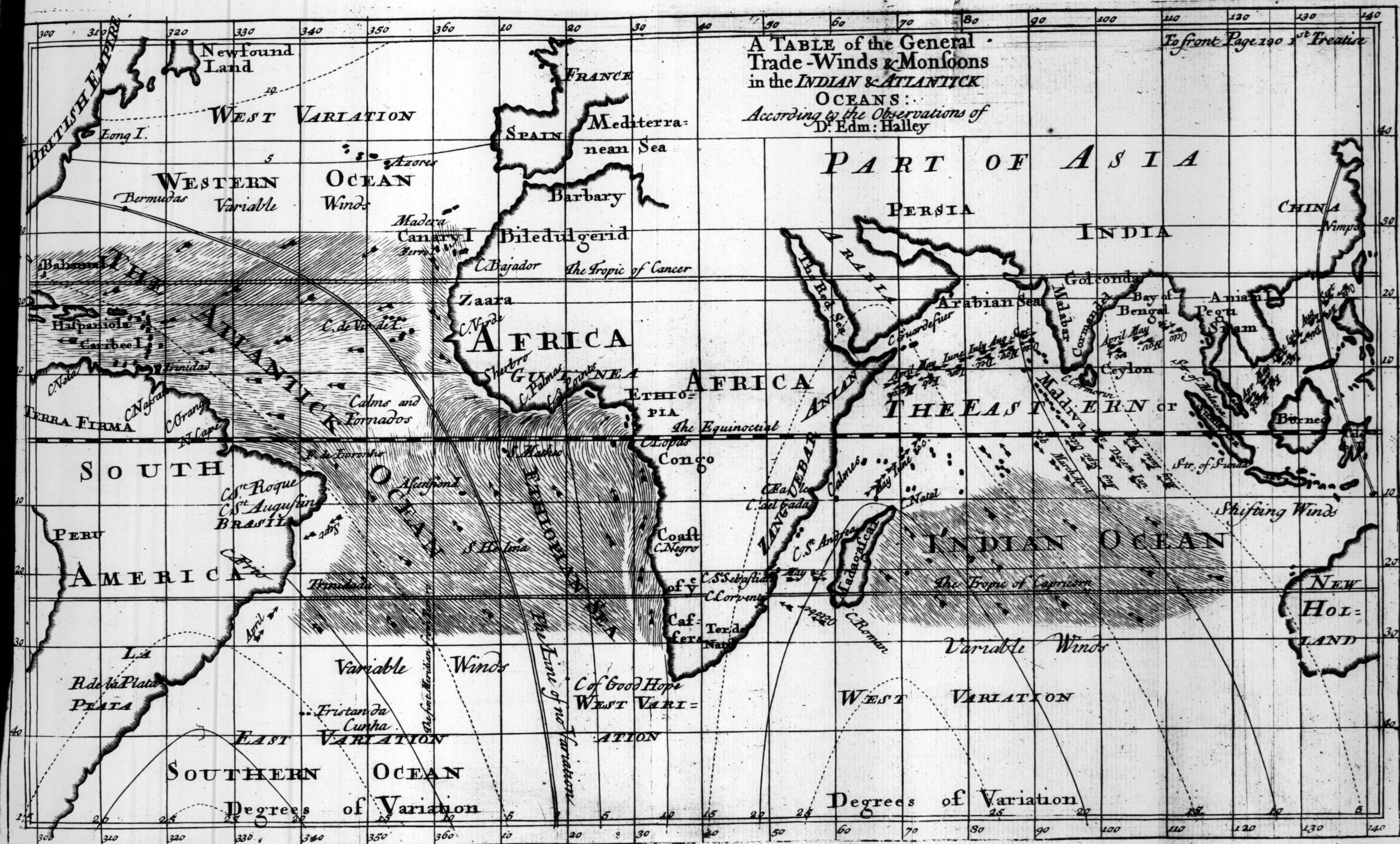
Guianean Coast : In others *thwarting* 'em much by their *transverse* Course from South North ; as on the *Western Shores of Angola* and *Peru*, for a *Thousand Leagues* together : others, blowing directly from the *Opposite Points*, as along the *Southernmost Part of Guinea* from *Sierra Lione* to the *Bottom of the Bay* and all this perpetually.

Yet in the *Indian Ocean*, these *Sea-bred Gale* become of so *complying* a Temper, as to yield readily to the *Periodical Insults* of its *Eastern Trade-Winds* ; and withal, as respectively supply all the *Vacancies* left behind 'em in their *Absence* ; which answers the utmost Enquiry yet made into the *Phenomena of Winds* and shuts up this *last* of my *Three Preliminary Discourses*, to the finding out of the *Immediate Causes* of the various and irregular *Motion of the Sea* it self, which occasions 'em.

Conclusion.

TO sum up, in short, this *Tripartite Discourse* at once, in order to introduce the next of the *Motion of the Sea*.

First, *Springs*, as consisting of *Water*, which is *Fluid*, to pierce the *Surface* of the *Earth* and *Heavy* to sink it into its *Veins*, must *Originally* descend from the *Sky* ; and as it falls in *Drops* innumerable, so it penetrates it by many *Holes*, which, being united underneath, must gather into *Rills*, and convey'd farther still swell into *Streams* of a larger size, till they break forth into the open *Air*, either on the



accord, or let off by the Miner, with-
 y farther Supply, than *Rain*; or other
 igation than their different *Descents* afford;
 it is, to enquire after *more* Recruits or
 ers of 'em, unless to puzzle and perplex
 who otherwise (if put at first into the
 Road of Knowledge) wou'd daily im-
 their Thoughts, for the good of the

ndly, It as plainly appears that *Rain* is
 ed, in invisible *Atoms*, indifferently from
 Land, by the Rays of the Sun; which
 rate in their Fall thro' the Air, and are
 it were, in *Moulds* of a larger Size,
 eater Drops of another Species upon
 New Concretion; and these are again
 ld by the *Summer's* or *Winter's* Colds
 ail or *Snow* of as many Sorts: But to
 those *Atoms* of Water into *Storms* they
 e rais'd to a greater *Height*: And to
 a Quantity of 'em into *Tempests*; their
 being large, and their Expansion evenly
 ver the Firmament, and continued for
 Season; till the Air become unable to
 'em, either shuff'd together or in any
 posture.

y, To convert Air into *Wind* it sufficeth
 the grossest Part of it uppermost; and
 he Sun's Heat can advance it no higher,
 ain it longer, to let it fall again by its
 deration; only more or less obliquely
 he Perpendicular, as the Medium Air
 ow, and the Stock 'tis furnish'd with
 s: And towards that Point of the
 , that either the Course of the *Sun*, or
 clivity of the *Earth*, or the Motion of
 the

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the *Sea*, whereon it falls, shall farther appo
Or, in case of their *Indifferency*, the Po
its own *Weight* pressing downwards, and
resistance of the *Air*, growing still more ob
by *Oppression*, makes it wheel about cir
for the easiest *Descent* into *Whirlwinds*
Hurricanes ; from the *Weight* of the Matter,
the *Height* of its *Fall* ; as is manifest.



THE
Second Treatise.

OF THE

T I D E ;

OR THE

BING *and* FLOWING

OF THE

S E A ;

WHEREIN,

its various Appearances
are Clear'd, and Difficul-
ties Solv'd.





THE

Record Treasury

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THE PREFACE.

being already adjusted, and settled the Preliminaries of Springs, Rain, and Wind; as Origin, Generation, and Production; now to treat of the Motion of the Sea in General before I can branch it into Particulars, in order to the immediate Causes of the Tide: I shall not to embroil the Matter in Hand with unnecessary Disputes, a Method is to be propos'd and follow'd; and that which I have actually pitch'd on, whether not usual, or pursued farther than ordinary, I shall here unfold it before I begin; and at the first step, annex Reasons for my proceeding after this manner; that the Reader may never lose himself following it, or be out of his Way.

In regard the Sea is subject to another Motion, I shew, (for Distinction's sake) that whereas that other tends always Westward; the Tide, Flows and Ebbs reciprocally North and South; that is continual; this Period, that depends on the Trade-wind, this Course of the Sun, and Moon; and that which has been discours'd on already, (when we treated of the Seasons) as to the variety of its Declination North and South, becoming of a quicker Motion, I first remove it out of the way; that, when

The P R E F A C E.

when it chanceth to interfere in our following
course, with the Motion of the Tide, it may
sily distinguish'd from it, in some of those Re-
to prevent Confusion.

Secondly, *Whereas the Tide is liable to Disorders, occasion'd by the irregular Situation of the Coasts, and Shores: To prevent the framing of a wrong Notion thereof, on that Account, I am free from all such Restraint throughout my Chapter; by supposing our Globe to be all round with Water, without End, or Limit, to give free Liberty for the Moon, to raise the opposite Tides daily, with One Revolution; for the Sun, to increase 'em twice monthly; and for the Planets, to raise 'em jointly, to raise 'em higher than ordinary, at several times every Year.*

Thirdly, Since the Universal Ocean is divided into Three Parts; and these are separated by great Tracts of Land; and the Indian and Pacifick Oceans, are less known to Us, than the Atlantick, which consists of the Atlantick and Ethiopick Seas conjoin'd, and reacheth the Artick and Antarctic Circles; to allow the Tidal Flood its full Course either way, from the Equator, whence it is sent forth. Hereupon, I undertake to speak professedly of the Phenomena of the Tide in this Ocean, and only touch By of those which belong to the other Two: as to the Diffusion of its Flood on each side the Equatorial Line, I chiefly endeavour to analyse that Part which transfuseth it self over our North Atlantic Division, with the greater variety of Appearance, and lies more immediately under our Inspection.

Fourthly, *After the Arrival of the*
the European Coasts; and it has enter'd
and British Channels; I trace it around both
and pursue it to every Port, and follow

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rs, as far as they are Navigable; denoting all the Time, and Place of their Floods, with Diversity of their Phenomena, as seems to be all kind of Appearances, that can possibly be elsewhere, throughout the Universe: And I beseege the Reader, that all whatsoever may be animadverted on the same Grounds; I have industriously picked up those which seem'd most odd and intricate, and brought 'em to the Test of a due Examine, and found 'em at the Bottom conformable to the Principles.

Lastly, For Illustration's sake, I have drawn up a Table of the Course of the Tide, according to the common Tide-Tables, for all that Compass; and set it before the Eye, the Order and Progress of the Tide, at one View; for an Example, how to be in the like of the Tidings in all other Seas, which doubtlesly will be executed in Process of Time, as being no less Useful, than Satisfactory to the Curiosity of Mankind, tho' as yet never attended: Those, who drew not the Origin of 'em from the Equator, not knowing where to begin their Work; and those who did that, apprehending not how to end it; Especially, being all the while involv'd in that vulgar Error; viz. That the High-water upon the First Meridian, is the same there and there, at the same Instant.

As far I argue, from the Cause to the Effect; That the Moon's Pressure upon our Atmosphere, makes the like Impression upon the Earth underneath it: Again, that the Depression of the Equator (after the same manner) raiseth the dependent Tides between the Tropicks and the Polar Circles: Then, that the Tumour in the East transfuseth it self on the Coasts of Europe, &c. And entring our British, &c. Channels, fluctuates

The P R E F A C E.

fluctuates up in the adjoining Rivers, still any from Universals to Particulars ; yet, suppose the while, the Consequence to hold on the Contrary. viz. That if her Pressure be the Cause of the Tide in Thames, for Example, it truly cannot (for their strict Connexion, and free Communication,) in all the Rivers, and Seas, throughout the World : So that what I here suggest, is not imperfect in its kind ; but only requires a farther Application to all the rest.

Lastly, It is in vain (on the Negative Part) to search out other Causes, to interpose between the Pressure and the Sea, to obstruct its Operation, or in the least to interfere with it, as a Partner in the Tide's Production ; or to act consistently with it, by any other Means, than (as the Sun does) by way of Pressure, without acting Counter to it, as the Moon her self would do, in case her Planetary Light rais'd the Tide by Fermentation, while her Corporal Presence depress'd it at the same Time ; and the Sun wou'd do the like, if at the same Time he Rarified and Attracted the Flood by his Heat, and condens'd and protruded it into an Ebb, at the same Place : And as for the Motion of the Tide, or the Influence of Planetary Bodies, being concern'd in the Work ; they are demonstrated, by all, to be neither proper nor seasonable to any such thing. Now to my Task.



Second T R E A T I S E.

of the Tide ; or the Ebbing and Flowing of the Sea.

C H A P. I.

of the Ocean's continual Flux into the West ; and of the Cause of the Tide, and how it is effected, according to its full Extent.



SINCE the Motion of the Sea in general is divided, 1. Into a *Westerly* one, whose Flux is *Perpetual* ; and, 2. That of the *Tide*, which is *Periodical*, and still Ebbs and Flows reciprocally *North and South* : Now, pursuant to the account I have already given of the Production of the *Wind*, in the precedent Chapter, I to proceed in *this*, (of the Motion of the) to demonstrate what Influence the *Wind* actually upon the former, with regard to continual Devolution into the *West*, as a
K
necessary

necessary Preliminary, before I enter upon the Motion of the *Tide*, which consists of a constant *Reciprocation*, Back and Forwards, between the *Equator* and the *Poles*; to shew whether they have any more *Dependance* on one another, than what is merely *Accidental*; and that the Tendency of the Former may perhaps, in some Circumstances, interfere with the Course of the Latter.

S E C T. I.

• Of the continual Flux of the Ocean from East to West, caused by the Wind; and that its different Motion from the Tide, neither concurs with it, nor obstructs it, as to the Substance of its Motion.

FIRST, Both Reason and Experience evince, that *Wind* and *Water*, being both airy and liquid Bodies, the one floating upon the Surface of the other, they must, throughout the Ocean, be every where very *Contiguous*; and by Consequence, in some measure *Coherent*, and very loath to be parted: Hence, it is, that the *Wind* inclines the *Sea*, in Compliance with its Motion, to retard or hasten its *Tides* into *Rivers*; and the *Ocean* never suffers any tumultuous Disturbance within it self, without Storms of *Wind*, and *Tempests* of Weather, to raise the Air to raise it.

Now, in regard the *Trade-Wind*, as directed by the Course of the Sun, blows continually *Westward*, and wafts over the largest Comp

the Earth ; it must needs drive the Surface of the Ocean, between the Tropicks, the same way : Hence the *Mariner*, in his *East-India* Voyages, which lie mostly within the Com-
pass of that Climate, is forc'd to quarter the course of the Sea, as well as the Wind, to get
thither ; and at his Return, he makes the best
of his way, both being favourable ; or else his
Arrival in *Europe* would be so late, as to miss
the Market.

Besides, That vast Body of Salt-water,
whereof the Ocean is compos'd, being Ponde-
rous as well as Self-coherent, must needs be flow-
ing and receiving the Motion of the Wind, and as
soon as it hath to part with it ; and consequently, the
Course of the Water is continued towards the
West, the more it must be increased, at least to
an indeterminate Height : Hence the *Mariner* well
knows, that the Mean Course of his Ship is
shortened in the same Proportion ; sailing
from *Europe* to *America* in a much shorter Time
than he can make his Return ; and his Voy-
age from the *East-Indies* to *Brasile* spends scarce
half the Time that it does back again ; but
passeth from *Peru* to *China*, thro' the *Paci-*
fic, (where that Wilderness of Water has free
Liberty to rowl before the Wind) Three Thou-
sand Leagues in Eighty Days, with much less
Labour either of Sail or Oar, than is accusto-
ry in other Seas.

And, forasmuch as the continual Flux of
the Ocean into the West, still raiseth a Protube-
rance on the Sea's Superficies, before the Wind ;
which is continued, as far as the Ocean lies
that way, to receive it ; its Surface must
along be proportionably advanced, and the

longest Course must raise it to the *highest* Pitch; Hence it is, that the Flux of the *Atlantick*, from the *African* Coast to the Bottom of the *Bay of Mexico*, makes such *Haste* thro' the *Caribees*; and the *Pacifick* does the like, from the back side of *Peru* thro' the *Anian* Gulph. But the Course of the Ocean, from the *Pacifick*, along the *Indian* Sea, towards the *Magellanick* Streights, being the *farthest* Drift, pours down the *strongest* Stream, and with the *greatest* Precipitation that can be found else where, as falling from the *greatest* Descent.

And since the Protuberant Flood before the Wind must needs leave as deep an Ebb behind it, yet cannot possibly return back exactly the same way, to supply that Vacuity; the Protuberance must force a Passage back again underneath itself, by the Preponderation of its own Weight, to devolve its Stream into the East, and reduce, in some measure, the Surface of the Sea into its Natural Posture, by an alternate Revolution; still rising higher on the one Part, and returning faster towards the other; the general Surface of the Ocean mounting all the while higher towards the West, especially between the Tropicks, where the Wind and the Sea keep better Touch with one another.

Such is the Motion of Undulation, that, (to preserve the Water's common Level) how much soever it is raised above it, by Result from any Depression; and is waved forward by Protrusion, it is as constantly devolv'd back again underneath, by way of Restitution: And for witness of this Return, after Marten-Mere in Lancashire was drained to a few Inches deep; its Bottom

ing near a Water-Level, a Gust of Wind, in one Night's space, drove twelve Hundred Acres of it to a New Ground, as having not competent Depth of Water to devolve it back again at the same Time; and there it remain'd, till the Wind ceasing gave it liberty to return whence it came.

Yet, in regard the Sun spreads the Influence of his Rays beyond the Limits of the Torrid Zone, at once over the whole Extent of the Hemisphere; the depending Wind must, in some degree, affect the Sea with a Motion universal; that is, from the one Pole to the other: Whence it is found by Experience, that wherever there lies a Passage open Westward, out of one part of the Ocean into another; the Current still holds on its Western Course thro' it, without any return; as appears in the Course of the Magellanick Gulph, which flows constantly out of the Atlantick into the Pacifick Ocean; and the Pacifick hasts again as it, thro' the Anian Streight towards the Atlantick, the one near the Arctick, and the other near the Antartick Circle; both running Westward.

This Flux of the Ocean holds on universally Westward in every free and open Sea, where the declivity of some transverse Shore deflects not the Course any other way; as it manifestly appears in our North Part of the Atlantick; whose North-west Coast of Guiana, from the Mouth of the Amazonis, declineth above Thirty Degrees North-Latitude, before it reach the Bottom of the Bay of Mexico: And the Flux of the Ocean bearing up against it all along from the West of Africk, passeth in a Crowd thro' the

The Ocean's Westward-Flux

Caribees, North-west ; and is reflected from the Bottom of the Bay North-East thro' the *Antilla* with the same Violence and Precipitation, till it transfuseth and loseth it self in the vast Expansion of the Ocean whence it was first rais'd to re-furnish it again with its Quota of Water and compleat its Circulation : an Expedient which turns doubly to the *Mariner's* Account to fall down by the South-Current, from the Latitude of the *Canaries* into our Western *Plantations* ; and when he is Homeward-bound the North Channel serves as well for his speedy return Thither.

And for an Experimental Evidence, that such a Contrariety of Motions is *compossible* in the Ocean, we have 'em All compriz'd within the narrow compass of the *Bosphorus* ; which has alike Two contrary Currents, one on the East Side from South to North ; and another on the West from North to South ; according to the different Direction of the opposite Shores so that rowing over the Channel, you are either carried out of the *Euxine* into the *Propontis*, or back again, while the Middle Stream runs both ways at once ; the Upper Six Foot of its Current (which riseth out of the *Euxine*) sliding over the Lower Part of its Stream from the *Propontis*, which forceth its way back again all the while underneath ; the Fresher and Lighter Water of the *Euxine* Sea floating upon the Top, while the Salter and Heavier of the *Agan* sinks to the Bottom.

Such Variety of Fluxes, To and Fro, and Up and Down, with their Circulation, and all of the same Nature, and arising from the same Cause

use, being experimentally *compossible* and *Practicable*, within the small compass of so *Narrow* and *Shallow* a *Gullet*; what can be objected against the above-said *Western* Flux of the *Ocean*, and that *North* and *Southern* one of the *Tide* (being *Motions* of *different* *Natures*, and proceeding from *several* *Causes* *independent* one another,) taking their full range in the *Extent* of the *Ocean*, without interfering? That they are necessary *Truths*, and *Geometrically* evident, so as not to be question'd. The *Former*, proceeding Originally from the *Sun's* *Heat* rarifying the *Air*, and driving Flood into the *West*; and the *Latter* being caus'd by the *Pressure* of the *Moon*, and toss'd from the *Equator* towards *North* and *South*, and striking again alternately: That floating upon the surface of the *Sea* all the while; *This* diving down into the *Deep*, and rising up again by *undulation*; That constantly affecting the same place, and always alike; *This* being *Periodical*, and making its *Visits* here and there with *endless* variety, &c. as I have already shewn of the *Former* in this *Section*; and shall do the same of the *Latter*, occasionally by degrees, throughout the following *Discourse* upon that subject.

Notwithstanding, since we find by Experience, that *Winds* of other Sorts sometimes *hasten* or *retard* the *Motion* of the *Tide*; sometimes *swell* it to an extraordinary *Height*, or *abate* it as much; and sometimes drive it with more violence against one *Shore* than another, with an *endless* variety: We must needs acknowledge, that the *Trade-Wind*, which has a more even and constant *Motion* than the

The Ocean's Westward-Flux.

Rest, *Westward*, sometimes *deflects* the Course of the Tide from its true North and South Declination from the Equator some Points *Westerly* yet without sharing in the Causality of its Substance, or being an *Impediment* to its proper Motion more than by *Accident*, or by way of a *Modification* to its Effect.

Just as a Stone cast into a standing Pool, raises an *Undulation* perfectly *Circular*, which the Stream of a River wou'd have formed into an *Oval Figure*, by sharp'ning it *before* into a *Hyperbole*, and blunting it *behind* into an *Ellipsis*, and compressing it on each Side *Parabolically*; rendring the whole Figure an imperfect Compound of all the *Curvilinear* Compositions, yet without being even a *Partial Cause* of the *Undulation* in itself; so the Trade Wind, and the Course of the Ocean pursue thereto, barely *Modifies* the Tide as to its extreme Parts, inasmuch as it affects the *Shores* and floats upon the *Surface* of the Water, without exercising any Causality upon the *Substance* of its Motion, which dives *underneath* it.

SEC

Causes of the Tide.

13

SECT. II.

*The Tide is caused by the Moon's Pressure
on our Atmosphere; and how it is effected.*

To disclose the true Cause of the *Ebbing*
and *Flowing* of the *Sea*, as contradistinct
the *Flux* and *Reflux* found in those *Rivers*
have an immediate Communication
it, and cannot be discover'd out of their
Parallels; at least the Motion of *Undulation*
needs be admitted in the *Ocean* it self; for
as the *Flux* of the *Sea* necessarily de-
parts from a higher Station; and the *Reflux*
again returns to a Lower than those *Ri-*
vers which they affect; and by consequence,
the surface of the *Sea* must respectively rise
and fall from the one extreame to the other:
in regard the *Sea* is a *Ponderous* and *Ina-*
Body, the Motion of *Ascent* and *De-*
which is merely *Local*, must be forced
it by some *Exterior Agent*, while its own
Propension to a mean Situation, still
fours to re-settle It in its *Natural Posture*,
it produceth that *Alternate Vicissitude* of
location, which affects the *Tide*.

To assign the said *Mean*, its proper Si-
tuation: For as much as *Salt-Water* is a *heavy*
element, and of a *liquid Constitution*, its Sur-
faces must naturally sink all over to an ex-
treme, and keep its extreme Parts to an
equal Height. Again, in regard the *Earth* and
conjoin'd compose one *Terraqueous Globe*;
and

and consequently respect *one* and the Point for the *Center* of their Gravity ; the *perfcial Level* of the Water cannot be *Plain*, but *Curv'd* or *Sphærical*, to keep its *extreme Parts equidistant* from it, and hold *Libration* on all Sides in an *even Poise* : Hence it follows, that whensoever any *Depression* is made in one Place, it must raise as big at least an *Equivalent*, *Rebound* in another, and both must be finally reduc'd to a *Level*, by the innate propension of its Gravity, and that so constantly and necessarily, that to advance any *permanent Protuberance* upon the *Ocean's Surface*, is so gross and groundless Error, as not to deserve the regard of a *Refutation*.

Hence it follows, that the *Motion* of a *Tide* may be caus'd alike by *Alleviation* or *pression* ; for whether the *Surface* of the Water be *Alleviated* or *Depress'd* from its *Natural Level* ; it must, by the *Laws* of *Restitution*, turn back again *thither* with the *same Force* and *Speed* ; and repeat its *Undulations* to the *same Height* and *Depth* ; and both ways must return back to their *Natural Level*, at the *same Rate*, whether they be rais'd by *Alleviation*, or else by *Rebound*.

But, in regard *Depression* proceeds immediately and necessarily from the *meer Application* of some other *Body* to the *Superficies* of the *Sea* ; the *Pressure* of the *Moon*, v. g. may be admitted for the *Cause* of the *Tide*, and may be pursued, as far as it will go before we have recourse to the *Sun's Rarefaction*, *Magnetic Attraction*, *Inexplicable Influence*, *Occult Qualities*, or *Motion* of the *Earth* ; whose *Existence*

Flux and Reflux or Tide.

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questionable, or Co-operation uncertain ; consequently, not to be admitted without most Assurance of Reason and Experience. Hence,

ndly, Touching the *Exterior Agent*, which Pressure upon the Sea's Superficies, and is contrary to the *Natural Propension* of *own Gravity* ; the ambient *Air*, or our *Atmosphere*, first occurs to be accepted ; as being *contiguous* and *Co-extensive* both to Land and Sea ; and *equivalent* in Weight to *Thirty* of *Quick-silver* in the *Barometer* ; or to *three* Foot of Water ; and, by consequence, much more than suffice to make the *Tide* ; but by depressing the Ocean *everywhere* at *once*, and in all Places much *equally* ; it rather keeps its Surface *Steady* in its *usual* Posture, than drives it into any Dis-

to ascend to the *Higher*, and more *Elevated* Region of the Air, which is immediately *contiguous* with the *Lower* ; it cannot depress the *Atmosphere* more intensely in *one* Place than *another*, as being *equally* co-extended to *all* Places at once, and every where *Equilibrated* to itself ; and so cannot make any *Inequality* in the Surface of the Sea underneath, by its *Intrinsic* Power, which is so *indifferent* to *all* Places, that it cannot *particularly* affect any *one* more intensely than the Rest, within the Hemisphere.

However, this *Ethereal Space* of the Air, being of Matter as well as Form ; and being a *substantial Body*, endowed with all its *Dimensions*, *Length*, *Breadth*, and *Thickness*,

ness, purposely to take up room ; how and *Subtle* soever it be, it must be Com- by a constipation of its Parts ; and *Elastic* their Relaxation ; and consequently ca- of receiving *such Impressions*, from any *Sun* *Planetary Bodies* passing over it, and of *mitting* 'em into the subjacent *Air* or *sphere* below ; to be derived to the Surface the *Sea* underneath ; as also of having *taken off* again *Periodically*, to cause that and *Flowing* in it which is called the *Tide*.

Now, in regard the *Moon* moves in the *east* Sphere of all *Planetary Bodies* ; and her *tion* is *Concentrical* to our *Globe* of *Earth* *Sea* conjoin'd ; and so at her *Nadir*, she *ther* distant from any determinate Place on by a whole *Diameter* of the *Earth* ; at her *rising* upon the *Horizon*, she still re- distant from the same more than *half* so than after she is arrived to its *vertical* P. And again, the *Lines* of her *Pressure* where are *shortest*, they become most *direct* and *compact*, to make the *deepest* *Impression* upon *Aether* ; and by its *Mediation* upon our *sphere* ; and this also upon the *Sea* itself ; a *parity* of *Reason*, must be continued around the *Universe*, from *one Meridian Westward* to *ther*, correspondently to her *Diurnal Course* be still *repeated* at her return to the same *indefinitely* without intermission : So much the *Tide* do also.

Besides, the *Approximation* of her *Orbit* *Sea* gives her power to act upon it with *Energy*, more than all the other *Celestial* *bodies* which lye scatter'd over the *Heaven* far *greater* distance from it ; without any

termination to the said Effect : And the position of her Sphere, between the Sea and the Moon, must needs obstruct their Influence on the Tide as much : So that the Motion of the Tide little regards any other Influence besides ; as we find by daily Observation, and will be fully demonstrated hereafter.

Now, on the one Part, as the Pressure of the Moon is the most proper and effectual Cause, to produce the said Effect ; so the Ocean is the most disposed Subject possible to receive it ; as being its Spherical and Natural Level, by the Equilibrium of its Surface, which is most easily taken away by the Moon's Pressure : And still reciprocally enforc'd upon it in one Part as it is abated in another ; the Element of Water (the Matter whereof it consists) being infinitely voluble by the Extent of its Surface, and the profundity of its Depth : And, in regard neither the Cause wants the Medium due Application ; nor the Subject a fit disposition for the Effect ; that it should not follow is absolutely impossible.

And manifest it is, That the vast Body of the Ocean cannot be hurried from our Nadir up to our Zenith, and from thence to our Zenith ; and then posted down again into the West, and then to the Place whence it came, in Twenty-four Hours space, without raising as vast a Motion in the Medium thro' which it passes ; and that she shou'd be so nearly obtruded from our Sight, and snatch'd away again from our Sight, to so vast a Distance, and with so great Dislocation of the Parts of the Medium, to make room for her Reception, and fill it up again at every Instant ; yet, that this Turmoil

moil should not cause the *Tidal Alteration* the *Sea's Superficies* underneath, is another possibility.

Hence the Motion of the *Tide*, pursued by her *Pressure*, does not barely correspond to, as the *Thing signified* to the *Sign* which presents it ; but necessarily depends upon the true and real *Effect* doth upon its Cause ; that is to say, at all *Times* and in *Place*, according to the manifold *diversity* of *Motion* ; as is found by *Observation* : forasmuch as the *Periodical Increase* and *Decrease* of its *Floods* and *Ebbs*, exceed the momentary *Energy* of her *Pressure*, both by *Excess* and *Defect* ; the *Difference* arising from another Sort of *Pressure*, interfering with hers, without recourse to any other kind of *Causality*, which would be either *impossible* to give her any *Assistance* towards the performance of her *Work*, either as to the *Whole* or any *Part* of it ; as will appear hereafter : Now, to shew how well qualified *Pressure* is to produce the *Tide*, as to its *Distance* ; or, inasmuch as it consists in a *Balance* between the *Two Extrems* aforesaid ; is the present Task to explain it more fully in the next *Section*.

S E C T. III.

*efficacy of the Moon's Pressure upon the Sea
the Tide's production ; and its several Qua-
tions for that purpose.*

put the *Sea* in its best *disposition* to re-
ceive the Effect of the *Moon's Pressure* ;
when her *first Impulse* finds the Surface of
it exactly *smooth*, and profoundly *quiet* ;
the extreme Parts standing throughout in an
Equilibrium, it is in the *readiest Disposition* to
sink *below* its *Spherical Level* ; and in the
Posture to rise again *above* it (as a *Pendu-
lum* best disposed for Motion To and Fro,
it hangs *perpendicularly* :) and by the *first*
it is better prepar'd to receive a *Second* ;
being regularly apply'd sinks the *Sea's*
Surfaces *lower* ; and gives it an *Additional*
to spring it self up again *Higher* than
before : And so upon her *third Impulse*, its
Ascent and Descent still increase in a *Progres-
sion* ; till the *Active Force* of the
Pressure, and the *Passive Resistance* of the
Surfaces arrive to an *Equality* ; and
their Progress is at a *stand* : Just as a Pen-
sion mov'd by *Clock-work*, requires the help-
of the Artificer to set it on foot ; and
that, it continues to raise its *Vibrations*
higher and higher, till their Motion becomes
equal and constant ; and so continues
ever.

Next,

Next, the *Aether*, which intervenes between the *Moon* and the *Sea*, being a Corporeal substance, of how *thin* and *rare* a Constitution; yet it must grow *denser* and *harder* by *pression*; not only to *transmit* her *Pressure* to the *Sea*, but also to *enforce* it downwards all that space; and the *quicker* the *Impression* the *deeper* *Impression* it must make. Hence the great *Celerity* of the *Moon's* Progress, her *Uprise* in the *East* till she reach the *dian*, must drive all the while her *Impression* more *forcibly* to the *Head*, in that *gross* and *heavy* Element of *Water*: As *Fire*, so *rare* a Substance as it is, dislodged out of the Mouth of a Cannon, by the excess of its *Celerity*, makes a violent and irresistible *Concussion* in the much denser *Air*. In like manner, the *Aether*, though *rare* and *light* in itself, yet, by the *Moon's* pulse, may make a deep *Depression* on the Surface of the *Sea*; as well as the *Air*, though it is *Hundred Times* lighter than *Water*, prepares *Quicksilver* in the *Barometer*, which is *twelve times* heavier than it, in proportion to the Poise of its own *Weight*, conjoin'd with the Multitude of *Vapours* and *Exhalations*, which it sustains.

Besides, the *vast Depth* of the *Ocean* stooping its *Bottom* so low, renders the *Body* of *Water*, which it sustains, more *pliable*, and better *disposed* for *Depression*: proportionate *Length* and *Breadth*, by diffusing the *Shores*, affords its *Middle* *Streets* equal *Liberty* to expatiate it self *more* every way. Again, whereas those *Shore* *Bottoms* are *fix'd* and *stedfast* by *Nature*, the *Water* contain'd within their *Compartments*

veable, and cleaves close to 'em on all Sides ;
 e Points of their Adhesion serve as Centers,
 the Lines of Water (which are loose at the
 her End) to turn upon 'em, as so many Ra-
 s's upon their Axes, which the farther they
 extended the faster they move, and the
 ilier they are set on foot. Hence it comes
 pass, that the Broader and Deeper the Ocean
 the easilier it must submit ; and the Lower it
 st stoop its Surface to the Pressure of the
 on ; and still Lower beyond comparison than
 our Narrow and Shallow Seas, as is found by
 servation.

Again, as to the vast Extent of her Influ-
 ce : Her Lines of Pressure (no less than the
 ams of her Light), are poured down, He-
 spherically, upon the whole Superficies of the
 ean at once, which makes their Impression
 h strong and comprehensive, as being the Ade-
 te Effect of so universal a Cause ; and must
 extensively affect all the Seas and Tides on
 half of the Globe at the same time, and
 verfully too, by their direct Impulse ; as well
 the Beams of the Sun, reflected universally
 in the Earth's Superficies, suffice to raise
 great a Quantity of Water into the Air, in
 Day's space, as wou'd suffice to furnish all
 Rivers in the World (according to their
 inary Course) with a Week's Expence of
 ir constant Stream : Yet, forasmuch as
 eral Causes are not apt to produce particular
 ects without some special Determination ;
 since the Ocean's Surface cannot possibly
 rais'd or depress'd in all Places at once ; the
 Pressure must differently affect 'em. Hence
 the contrary) in the Production of the
 L Finally,

Finally To determine this smart and universal Pressure, to affect some one Place of the Sea more effectually than the rest; it is farther to be consider'd, that the *Earth* and the *Moon* be alike of a *Globous Figure*, and consequently a *Convex Superficies*; the *Lines of Pressure*, falling down from the Body of the one, must fall upon the Surface of the other at *all Angles*: Those that fall *perpendicularly*, as being the most *direct* and *compact*, give the *smartest* Stroke, and make the *deepest* Impressions wheresoever they light; whereas, the rest which descend from 'em, growing more *Oblique* and *dispers'd*, suffer a Tumour to rise *circularly* about the Point depress'd; which, if she be at the *Equinox*, must fall *perpendicularly* upon the *Equator*: And, in regard the *Moon* is continually in Motion towards the *West*, the said Point depress'd must follow her in the *same Tract*; and lineally describe the *Equator* it self (as follows its direction) *Westward*: And since every near Depression must raise a *correspondent* Tumour on each Side thereof; the *Undulations* so raised must lye extended from *East to West* in *Lines parallel* to the *Equator*; tho' they move To and Fro, with regard to *North and South*.

After all, those Two Waves, swelling *collaterally* on each side of that *Equinoctial Depression*, and having *free liberty* to move respectively towards the *North* and *South* Poles, must still raise and dilate their *Undulations* by *several Ways* at once, as long as the Pressure continues; and upon its *Relaxation* they are to *flow back* again into the *Vacuity* left behind.

on the Equator ; and their Motion having
quir'd its utmost Celerity by their Descent, can-
not stop in their Congress, but must proceed to
mount one joint Undulation, at least to an
equal Height with those Two which rais'd it
towards the Poles ; as being the Counterpoise of
their Libration.

So easy is the Element of Water to be
brought upon, and so ready and well dispos'd
to the Spherical Situation of the Ocean's Sur-
face, to receive any Impression from an Exteri-
or Agent : And withal, so powerful are the
Advantages wherewith the Moon's Pressure is
equipp'd to operate upon it : And so Connatural
the Manner of their Operation to the Pro-
duction of the described Effect, that it cannot
fail but follow accordingly.

Or, on the contrary, to suppose that Co-
mension of the intervening *Aether*, whose Dia-
meter is equal to that of the Moon's Orb, and its
Area as large as the Planisphere of the Earth,
should be contracted in Length, by her Pressure
on our Globe, its full Semidiameter in Six
Inches space ; nay, be pitch'd upon our Hemi-
sphere and taken off again in Six more ; yet
the Sea's Superficies, which sustains a propor-
tionable share of the Burthen all the while,
should neither be depress'd by the Application,
nor alleviated by its Removal ; nor suffer any
Impression from its Impulse, so harden'd by its
Gravity, and sharpen'd by the Moon's and the
Sun's Convexity, (as it were on purpose to
do it ;) That, (I say) the Element of Water,
so easily to be wrought upon, and its Surface in
the most yielding Posture of its Equilibrium, and
so vast an Extent, shou'd, notwithstanding,

refuse to *resent* the Energy of her Operation in so advantageous Circumstances ; implying that either the whole *interjacent Space*, that discriminates her *Atmosphere* from ours, is a *vacuity*, and contains *Nothing* at all in it, destructive to the Complex Constitution of the *Universe* : Or, that a *powerful Cause*, duly apply'd to a *well-disposed Subject*, shou'd not actually produce its proper Effect : which includes *Contradiction*, and is *impossible*. But this Point being gain'd, as to the *Substance* of our design'd Effect ; let us try what *farther Advance* can be made for its daily *Increase*, from the *Consistency* and *Regularity* of its Cause's Application. Yet, nevertheless, the *following Rub* remains to be remov'd out of the Way.

Objection from the Weather-Glass Solution

TO lessen the Force of the *Moon's Pressure* upon the Ocean, it is objected that *Quicksilver*, tho' it be rais'd in the *Barometer* about *Thirty Inches*, by the Weight of the *Atmosphere* ; yet it is not sensibly advanc'd *higher* in the Tube, by the supposed *Additional Pressure* of the Moon : And, whereas the *Tide* riseth not *Five Foot* at one season, and another exceeds *Fifty* ; the *Quicksilver* takes not the least notice of any *Variation* ; which seems to evince, that either it is not rais'd by the *Pressure* ; or the *Quicksilver* in the *Barometer* wou'd make us *sensible* of the Operation.

To remove this Rub out of our way, on the Part; viz. That the Quicksilver is not mov'd by the Moon's Pressure: the Mineral is five times heavier than Water; and, by consequence so much harder to be rais'd: Again, it exceeds Water no less in Consistence than in Gravity, and so must be Twenty-Four times less voluble, by way of Undulation: Moreover, it grows much harder to be moved within the strict confinement of a Tube, of no more than the Fifth Part of an Inch Diameter: Besides the close Adhesion it has to it on all sides at once; as appears by the protuberance of the Blebb in the Middle, while it riseth; and the Cavity of the Depression, when it falls in; yet all those Reluctances are jointly to be overcome at the same Instant, whensoever it is rais'd.

Whereas, on the contrary, besides the Levity of the Water it self, it is, in respect of the Ocean's vast Extent in Length, Breadth, and Depth, indefinitely Fluid; and so, is easily mov'd by Pressure, and mov'd no less effectually by Undulation; as Streams, the broader and deeper they are, still they become easier and swifter in Motion. Hence, the first Impulse of the Moon, having made any sensible Impression on the Sea's Superficies, that first Commotion is rais'd considerably higher by a second; and this by a third; and so progressively; still increasing to the reciprocal Libration of the Undulations; while the Active Power of the Moon, and the Passive Resistance of the other, come to an Equilibrium; which finds no Place in the Motion of the Quicksilver in the Barometer, for want of its first Effect; the leading

Pulse being quite *lost*, which shou'd occasion both the Birth and Growth of all the rest.

Hence it is no wonder, that neither the Pressure of the *Moon* shou'd give any visible Rise to the *Quicksilver*; nor the Weight of the *Atmosphere* breed any sensible Commotion in the *Sea*: For, altho' both act by Pressure, and very effectually too, when they are directly apply'd to their proper and well-disposed Subjects; yet nothing can be affected on the contrary: For, as a *Pound* of Lead in the one Pan of the Scales cannot be stirr'd by *Fifteen Ounces* in the other; so the Pressure of the *Moon*, being so far over-power'd by the Weight and Resistance of the *Quicksilver*, loseth its first Strength, and for want of giving a beginning to its vibration, all which follow are spent in vain. And as for the Weight of the *Atmosphere*, though never so much increased, it cannot impart any Motion upon the *Sea*, as being equally spread over its whole Surface at once; but rather keeps it steady in its Natural Posture.

But, on the contrary, admit the Weight of the *Atmosphere* were apply'd to the Ocean with the same Advantages that the Pressure of the *Moon* is; and the Effect would be advanced to a vast Excess: For, suppose the first Impulse shou'd depress the Ocean's Surface *Thirty Foot*, in proportion to the *Quicksilver's Thirty Inches* in the *Barometer*; to raise it by Rebound, an Undulation *Thirty Foot* above the Natural Level of the *Sea*; and the Sea should raise an Undulation *Thirty Foot* higher than the First; and the *Third* another as much higher, and so forward; or, allowing

Foot's Abatement to every Undulation fifteen
times together ; and the *Product* of their Rise
ould amount to no less than *three hundred*
thoms : so vast an Advantage doth the Pres-
e of the *Moon* make of its *constant* and re-
ar Application to the *Sea*, as shall be shew'd
the two following *Sections* ; and so utterly
the *Weight* of the *Atmosphere* defeated,
about it, of any sensible Effect wrought up-
the *Ocean*.

And all this while, the *Objection* runs upon
s double Mistake ; to wit, that the *Tide* is
sed meerly by the *Moon's* single Pressure,
m *Five* Foot to *Fifty* : Whereas, on the
e side it is depress'd so low, by the *Additio-*
y *Impulsive* Rays of the *Sun* ; and rais'd to
at Height, by the special Concurrence of the
tracting *Shores* ; acting counter to each other
several *Seasons* ; as will hereafter plainly ap-
ar, on due Occasions.

And if it be further urg'd, that neither the
fluence of the *Sun* or *Moon*, by way of Pres-
e, is as perceptible to *Sense*, as the least Blast
Wind ; nor, consequently, so able to produce
vast an Effect as the Motion of the *Tide*,
th all its Diversity. It is reply'd ; that, altho'
e *Weight* of the *Atmosphere* be no more per-
ptible to our *Senses*, than the aforesaid In-
e ; yet it is heavy enough in it self, (did
not alike support us on all Sides at once) to
ap us so close, and fix us so fast to the
round, that the strongest *Giant* wou'd be less
le to stir either Hand or Foot, than to re-
ove a Mountain : And, notwithstanding the
ind's quick Motion makes a forcible Impres-

sion upon our *Senses* ; yet, were it put to a peremptory a Stop by some *Obstacle*, as the aforesaid *Pressure*, is by the Surface of the Sea, 'twould not suffice to extinguish the Flame of a Candle.

And, as to the Production of the said *Tide* Effect: Since the *Wind*, notwithstanding the *Thinness* and *Levity* of the Air whereof it consists, compared to the *Density* and *Gravity* of the Water which is mov'd by it, falls so far short of matching it, as *One* does to a *Hundred*, yet, by *beginning* to ruffle its Superficies with gentle Blasts ; and raising 'em afterwards by *Degrees*, and still giving 'em due *Application* all the while ; can, within a *few Hours* space, disorder the *Ocean* into so tumultuous a Crowd of mountainous Billows, as 'twould crack all the *Engines* in the World, to sustain any one of 'em for a single *Moment* : 'Tis no wonder that the said *Pressure* so qualify'd, as I have already declared, shou'd by the said means of *reciprocal Libration*, and by the like progressive *Degrees* produce the more Periodical Motion of the *Tide* ; both as to its Substance and all its Diversity, according to the different Energy of its *Application*. Thus much being alledged for the Production of the *Tide* by the *Moon's Pressure*, in general Terms ; let us see how the different Motions of the *Moon* respectively influence the *Tides* of the *Ocean*,

S E C T. IV.

Diurnal Course of the Moon, and the Motion of the Tide adjusted ; and the Regularity of Pressure's Application demonstrated ; and she maketh a Primary and a Secondary Tide, with one Revolution.

HAVING already determin'd the Cause of the Tide in general ; and described in manner how it is produc'd : To observe the Cause and Method, I am now to give an Account of the Moon's *Diurnal Course* from East to West, as being her most Regular and Common Load about our Globe ; before I digress to her *Menstrual* and *Annual* Motions, which are Reciprocations from it, And, to speak intel-

It is to be noted (to have but one Idea in view at once), that I place the Moon in the Equator, as being the Mean between the Tropicks, which she never transgresseth Six Degrees : And (to hunt down one Fault before another be started), I make her Orbit to be *concentrical* with the Earth, whereas she produceth *two Tides* with one Revolution ; to describe their Production exactly, I shew how it is perform'd gradually in *four times six Hours* ; I mean *Lunar Hours*, which are about *two Minutes* shorter than the *Solar*.

And, forasmuch as they are produc'd by Pressure, which cannot affect (immediately and

and directly), more than the *one Half* of the Globe at once ; I assign 'em *Both* to the Impulse ; the one as its *Primary*, and the other as its *Secondary Effect* ; tho' they be produced by very different Means.

Finally, When I say 'tis High-Water on the *same Meridian* with the Moon, it is understood of that Tide which is caused by her *Rebound* between the *Tropicks* and the *Circles* ; as being caus'd by her *Pressure* which is made at the *same Time*, and upon the *Meridian*, near the *Equator*. Thus much I have now *Advertis'd*,

First, It is to be consider'd, that her *Pressure*, co-extending to our whole *sphere* of the Globe at once, begin at her *East*, to affect the Ocean upon the *Meridian* ; and as she mounts higher towards her *South*, those *Lines* are not only contracted in Length a *Semidiameter* of the Earth, but still grow more compact for the *Six Hours* together ; and fall more directly upon its Surface, to make a deeper depression in the *Sea*, between the *Tropicks*, till she is arriv'd to her greatest *Height* ; while the *Undulations* are rais'd by her *Rebound* laterally on each Side of her Passage, still swell and dilate themselves (till the *High-Water*) towards the *Poles*, till her *Pressure* be at a stand.

And for the *next Six Hours*, when she declines into the *West*, and withdraws her *Pressure* from our *Hemisphere* by the *Degrees* that she had advanc'd 'em ; the *Undulations* must devolve back again, with as

Pre

Flux and Reflex or Tide.

31

itation towards the *Equinoctial Line*; nor
to fill up the vast *Vacuity* left by her Ab-
but also to remount the Water's Super-
in the same Place, as high above the Oce-
natural Level as it was shrunk below it be-
that, as at her *Southing* was made High-
towards the *Poles*; so now, at her *Setting*,
upon the *Equator*.
In the *Six Hours* space after her *Setting*,
she is hasting to the *Meridian* of our An-
s, that *Equinoctial Tumour*, left behind
upon the Ocean on this Side of the Globe,
descend again by its own Weight, as low
whence it rebounded before; to make
at a *Depression* upon the Sea's Superficies
Hemisphere, and at the same Instant,
the Moon does upon theirs; to make two
rically opposite *Tides* at the same time; there
ary one, as caus'd by her immediate and
Pressure; and here a *Secondary* one, as
by the Descent of the said *Undulation* left
our *Meridian* at her *Setting*.
In the last *Six Hours*, while the Moon
is to our *Horizon*, the Sea on our side
Globe, which was *secondarily depress'd* to
west Ebb by its own Weight, rebounds
very opportunely to its former Height;
while the Tumour hangs as it were sus-
d in the Air, she may give her *Second*
a Regular Application, to drive it
again more forcibly, in a joint Concur-
with its innate Ponderation: And be-
is *Second Revolution* with more Vivacity
did the *First*; and the next with more
his; and so the rest that follow progres-
by a Circular Repetition; till they ar-
rive

rive at that stint which is to be *constantly* maintain'd, and as it were *repeated*, by an *Alter* Vicissitude ever after.

For, the Moon still renewing her Pre and taking it off again by *equal* spaces of Time at every *Six Hours* end ; and this *Primary* immediate Impression, setting its Stamp on the *Secondary* one, (which immediately follows it, and is produc'd by a concurren Depressiō of the Water's Gravity, as the *Adequate* Effect of its immediate Cause) each alternately *pursues* the other so close, as to leave no *Vacancy* in point of Time, to interpose between 'em, which the Moon's *second* Impression cannot supply, by the more constant and regular Application of her *successive* Revolutions.

But, after the Motion of the Sea be *adjusted*, by a few such Amendments, to the *common Course* of the Moon ; and the Undulations are rais'd to a competent Height by a proportionable Number of her regular Impulses, regularly apply'd ; they acquire a Motion *proper* to themselves, and become more *Equitemporary* ; let their *Librations* be never so much increased or diminish'd : yet they adhere all the while no otherwise to the *Course* of the *Moon*, than a good-going *lum-Clock* does to the *Sun* ; so as to stick to their *mean* Motion, let the *Real* One move how it will ; notwithstanding, so as still to attend their stated Occurrences to a Point : A convincing Argument, that as the Motion of a *Clock* has a dependance on that of the *Sun*, by the contrivance of *Art* ; so this of the *Tide* has its Dependance on the *Course* of the *Moon*, by the Order of *Nature* ; yet all this while,

regard to *Another* of their own, to *Qualify*
 and it is no less necessary, than that the
Increase and Decrease of Day and Night shou'd
 be on the *Rising and Setting of the Sun* ;
 the different Constitutions of the *Four*
Seasons of the Year, on his respective Arrival
 at the *Four Cardinal Points of the Zodiack*.

As far the Motion of the *Tide* is adjusted
 to the *Mean Time* with the *Diurnal Course of*
the Moon, whereon it depends ; and (foras-
 much as is yet consider'd) it shou'd keep to a
 certain *Height* ; but being found by Observa-
 tion to fall short of it at *some Seasons*, as much
 exceeds it at *others* : It is next to be exa-

S E C T. V.

The Tide's Menstrual Increase is caused by
Concurrence of the Sun's Influence with the
Moon, at her Change and Full ; and it's De-
crease for want of it, at her Quadratures.

H U S far I have described the constant
 Course of the *Tide*, as depending solely
 on the Pressure of the *Moon*, turning Con-
 centrically about the Earth ; and making the
 rising *Tides* constantly equal, without any
 variation : Now, in regard the *Menstrual In-*
 crease of those *Tides* constantly makes *highest*
 at *Spring Tides*, when she is either in *conjunction* with
 the Sun at her *Change*, or in their *opposition* at
 her *Full* : And the Decrease is at its *lowest Ebb*
 when

when she, is in her *Quadratures*; those Floods, by way of *Addition*, and the Ebbs by way of *Subtraction*; that neither an Effect may be put without a sufficient Cause, nor the Cause may lose its proper Effect.

Again, forasmuch as *Light* and *Heat* are the chief and most powerful Influence of all elementary Bodies; and the *Sun* particularly distinguishes himself from all the rest, in being the Sovereign Origin of 'em both; I demonstrate that his Rays, as impregnated therewith, are the most efficacious and proper Causes to produce the said *Tidal Variation*, and withal, that the Ocean is as well disposed to receive 'em.

First, Concerning the Sun's *Light*; its motion being progressive, and the Part whereof it consists extremely small, it passes thro' the Air down to the Sea, as thro' Glass or Crystal, without any great Impediment; yet since we find it strongly reverberated by its *Reflection* from the Ocean; we may infer it to be stop'd in part, and resisted spontaneously, in its Career, by the Opposition of the *Salt-Water*, as well as of any other material Substance; and to fasten Strokes upon it of a determinate Force; and what it was by its *Weight*, it redoubles in Effect by the Celerity of its Motion; and by this means, acts most powerfully upon the Organs of *Animals*; drives, as it were, Wedges of Heat into the Hearts of Plants, and Things Inanimate; separates their more Solid Parts: All which is confessedly the Properties of *Bodies*, and

belong to Material Substances; and consequently enable it to operate upon the *Sea*, as body does upon another; and powerfully due *Application* thereto.

in, the reflex *Heat* of the Sun seconds *direct Pressure* of his Light with a retorted upon the *Sea*; by raising *Vapours* and *Exhalations* into the Air, that gravitate upon surface of all Liquid Bodies; to that Degree to raise the Quicksilver in the *Barometre*; I say, the preponderation of the *Atmosphere*, 27 *Inches* (the ordinary Weight of the Air) up to 31, (which is the *Addition* of Pressure caus'd by the Energy of the Sun's Rays as is found by Experience; the Overplus of those *Four Inches* of Quicksilver being equivalent to *Four Foot* of Water; and equivalent to the Pressure which it imposes upon the Surface of the *Sea*; in proportion to what it actually exerts; which amounts to the Pressure of *Four Foot* of Water, spread over the whole Surface of the Ocean.

And, those *Vapours* and *Exhalations*, when they are rais'd, grow more *Ponderous* by recoiling against the Impulse of their Motion as a Pound of *Lead*, while 'tis only kept in the Air to the same Height, weighs more than a Pound; but if it be lifted up, it increaseth its Pressure proportionably to the increase of its Motion; as, on the contrary, if it be let fall again, its pressure diminishes as much, till at last it weighs no more than a *Feather*: Moreover, since the Sun moves not one half of his Diurnal Revolution in raising the said *Vapours* and *Exhalations*, as we find by experience, in the *Dews* which

which fall again *betimes* in the Afternoon Energy of his Operation seems considerably improv'd, that can raise so vast a Wave High, in so short a Time.

Secondly, That the *San's* Influence may fall short of producing its proper Effect on the Sea, for want of due Application, Heat and Light spread themselves over the Hemisphere, as *universally* as the Lines of Latitude do. 2. And also affect the Surface of the Ocean more intensely between the Tropics, and depress it by their Impulse more effectually and as remissly towards the Poles, to give liberty to rebound more freely there: But the Force and Efficacy of his Influence increases equally with hers, till Noon; and is quite taken off again, before Night; and in different Seasons of the Year, what each respectively gains at one Season it loses at another.

But, on the contrary, the different Directions of their Diurnal Revolutions divide and weaken the Efficacy of their Force, for want of due concurrence to produce the same Effect; for, at their Conjunction, his Rays and her Lines of Pressure, following the same Direction, send down jointly their most direct and compact Force, to raise the highest Flood, and the lowest Ebb; but the next Day, coming both up at once to the same Meridional Line, their Force being divided they fall short of their former Effect, by a Sixth Part; and at their Third return, more than that; and are progressively for Seven Days together, till the End of the First Quarter; the Motion of the

adhering to the Course of the *Moon*, as is
 and by Observation. But after her *Quadrature*, till their *Opposition*,
 Strokes of Light and Heat, and Hers of
 sure, fall upon the *Diametrically-opposite Un-*
 tions; and as diversly affect 'em, in their
 erent *Hemispheres*; hitting 'em daily more
 tly, and advancing 'em higher and higher,
 means of Depression; till the *Plenilunary*
 reach the height of That, at her *Change*;
 the *Manner* of their Operations be very
 erent: For, whereas at her *Change*, they
 , with *united* Force, in effect, a double-Im-
 e with one single Stroke, to *one* and the
 Undulation, letting its *Opposite* pass disre-
 ed: Now, on the contrary, at her *Full*,
 give their Strokes single and apart, to
 of the *Diametrically opposite Meridians*; to
 t *both* the Emergent Undulations at once,
 raise 'em to their *Novilunary* Height; by
 ucing the *same* Effect as before, tho' by a
 e *different* Manner of Operation: Just, as
 n a *Pendulum* is mov'd by a *Clock*; it mat-
 not, as to the *Effect*, whether it be rosd
 One way with a *double* Force, or *Both* ways
 a *single* One; for, in both Cases, its *Vibra-*
 are kept up to the *same* Height.

Lastly, While the Constitution of the Sea
 nnes in its *last Disposition*, for this *new*
 ession of the *Sun's* Influence; and the
 is kept *Actually* in Motion by the Pres-
 of the *Moon's Diurnal Course*, to receive it;
 ing else can be required to raise it, at *due*
 s, to a Height extraordinary, beside the
 said Influence, so apply'd.

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As,

As, when we have put a *Pound* into one End of the Scales, and endeavour to raise it by casting *Ounces* into the other ; tho' it staid not, till the Addition of the *sixteenth* *Ounce* brings both Ends into an *Equilibrium*, and the *seventeenth* overcomes the Friction of the *Axis* ; yet after That, every *Scruple* that is added gives an *Increase of Velocity* to its Motion : So in the present Case, be the Super-influential Power of the *Sun* never so weak ; yet, assisted by the afore said Advantages, of a Regular Application it sufficeth to advance the Ordinary Height of the *Tides* (which are already put into Motion and kept on Foot, by the *Diurnal Pressure* of the *Moon*) to an *Extraordinary Height* ; and serve to discriminate Each from Other, with the indefinite Variety of *Increase*, forward, till the *Luminary's Conjunction*, or *Opposition* ; and *Decrease*, back again, till her *Quadratures* ; successively, thro' their *Menstrual* Revolutions.

But, lest the Height of the *Tide* may rise too much Advanc'd at the *Change* and Full above that which happens at the *Quadratures* to be rais'd within the Space of *seven Days*, the additional Rays of the *Sun* : It is farther to be consider'd, That the Force which they add to the Pressure of the *Moon*, (by their Concurrence at her *Change* and *Full*), for the Increase of the *Tide*, is not only subtracted at her *Quarter-floods* ; but directly occurs, in the same measure, to suppress it ; so that the *Sun's* Influence causeth different *Tides*, at contrary Seasons, in a double Proportion to its real Force inasmuch as it does not only withdraw, what was *Auxiliary* before ; but renders it afterwards *Adverse* to the same Degree, by a contrary Application.

Hea

Hence it comes to pass, That the *Menstrual* Increase of the *Tide*, according to its whole extent, doubles the Highest, which the *Sun's* Force cou'd directly give it: Forasmuch as the *First seven* Floods, after the *first* or *last* Quarter, it only takes off the Impediment of *Opposition*, which is made to the Rising of the *Quarter-floods* to their usual Height: Whereas afterwards, for the other *seven* before *Change* and *Full*, by the joint *Concurrence* of Influence with *Hers*, they be as much added above it; and so by acting counter to it, at different Seasons, coextends to the whole by its contrary Application, as aforesaid. Besides, the superadded Assistance of *Inclining* and *Shores*, (which affect not the *Neap-tides* at all, that can hardly reach 'em); helps to raise these more *Advance Floods* to that extraordinary Height; as will more fully appear hereafter.

SECT. VI.

the Sun's and Moon's Annual Courses thro' the Zodiac, jointly diversify the Depending Tides, and raise the Equinoctial Tides higher than the

the Two precedent Sections has been shewn, *First*, The Application and Effluence of the *Moon's Diurnal Pressure*, to raise and continue the Common *Tide* to its constant Height. *Secondly*, How effectual the Accessory Light and Heat of the *Sun* has prov'd, for Diversifying those *Tides*, by way of Increase and

Decrease respectively, to their *Monthly* Aspects. Now, concerning their *Annual* Courses, the Obliquity of the *Zodiack*; It is farther serv'd, that all along their Progress, from *Tropicks* to the *Equator*, (where they send down their most *direct* and *compact* Influences, take their *largest* Compass about Our Terrestrial Globe); they jointly raise the *Intending Tides*, by successive Degrees, till they reach their *Equinoctial* Pitch, which surmounts all the rest; according to the Theory of the *Tide*, laid down already on several Occurrences, in former *Sections*.

But, to supply Now, what was omitted. It is farther to be consider'd, that the Planetary Motions being *Elliptical*, and consequently their Influences *more* and *less* Intense, according to their several *Distances* from Us; the *Equinoctial Tides* may be *augmented* by the Moon's *Perigeum*, and the Earth's *Perihelion*, and their *Apogeums* and *Aphelions*, may *anomalously diminish* them as much, whether they *Conjunctively* taken, or *Apart*, as it shall happen to an Indefinite Variety.

Again, Forasmuch as Strokes of the same *direction* make deeper Impressions, than those that are *disparate*; and the *Moon* sticks not so close to the *Ecliptick*, as the *Sun* does: Upon every *Approach*, or *Declination*, she makes Strokes more or less *Effectual*, upon the Surface: Besides, as by their Access to the Sun, and Recess from it, their Course, with respect thereto, is either *Accelerated*, or *Retarded*: The Motion of the *Tide* must, in some measure, be so too; with several other *Anomalous* Differences, both of *Excess* and *Defect*; which are ra-

Object for piercing Wits to discover, and for
the *Speculation* to manage; than a fit Subject
of *Experience*, and short-sighted *Observation*
employ'd about; so that they may here
be well omitted, where nothing more than
Utility and *Clarity* is intended.

But, what falls within the Cognizance of
the *Both*, is, that the intervening *Aether*, (by
the Means the Pressure of the *Moon* is sup-
posed to affect the *Sea*,) is of a *yielding* and *com-*
plaisant Temper; and withal, the Body of *Wa-*
ter which is affected, of a *ponderous* and *liquid*
constitution: Hence, the consequent Motion
of the *Sea*, cannot be suppos'd to keep *exact*
step with the Impulse of the *Moon*; but the
Motion which is rais'd, must fall short, both in
Time and *Speed*, of the design'd Effect: And
in every *Allteration*, either of *Speed* or *Cau-*
se, it must rather observe Her *Mean* Moti-
on than Her *Real* Course: As a long and heavy
Column, little regards the *Unequal* Draught of
the *Block*; but rather sticks to a more regular
Motion, in due proportion to its *Length* and
Weight, to keep the *Index* to an exact Time.

Moreover, When the Motion of any Liquid
heavy Body, is *gradually* Increased, by the
Force of *Reciprocal Libration*; it will go on
increasing, tho' not at the same Rate, after the
Force of the Mover begins to *abate*, till it come
to an *Equilibrium* with the Remainder:
And, the *highest Tides* regularly happen, *two*
Days after the *Change* and *Full*, when
the Force of the *Moon's* Pressure begins to *decay*,
they meet not with some *Anomalous* Impedi-
ment to stop their Career.

The Conclusion is, that the *highest Tides* possible must happen of Course, when the Sun is at his *Equinox*, and the *Moon* upon the *Ecliptic* and withal in her *Perigeum*; *three* or *four* Days after the *Change*, or *Full*; and must swell Highest, either upon the *Equator* at their joint Concurrence from the *Atlantick* and *Ethiopian* Oceans; Or, as I conceive, about 45 Degrees *North* and *South* Latitude, where their *Collected* Tumours most abound: And this *Recapitulation* Instance will serve well enough, to remind of the *Causes* already assign'd, for the *Increase* and *Decrease* of the *Tides*; from the *first Impressions* made upon the *Sea*, to their full *Advancement* to their *Equinoctial* Height.

But to proceed farther, to weigh the *Advantages* of the *Power*, which the *Sun* and *Moon* have to *Act*; and the due *Disposition* of the *Air*, which is the *Medium* that both conveyeth and enforceth their *Influence* upon the *Sea*; as also the *Capacity* of the *Subject*, to receive the *Effect*; with a *Liberty* to make such *Additions* and *Subtractions*, as the *Rational* Art direct, and the *Laws* of *Motion* allow, plainly appears, upon the *Principles* already laid, and the *Method* which I have followed, that the *Motion* of the *Tide* hath ever adhered, and must still stick close to the *Course* of the *Moon*, (in concurrence with That of the *Sun*) *Days*, *Months*, and *Years*; One *Age* after another, without any *Observable* Deviation.

C H A P. II.

*f the Tides of the Ocean, as being
bounded by Coasts, and Shores.*

SO punctually, as I have already demonstrated, wou'd the Motions of the Tide observe the Course of the *Sun* and *Moon*; and all their Diversities might as exactly correspond to each other, according to the *Scheme* we drawn, if the *Extent* of the Ocean's Superficies were *boundless*; and spread *Universally* over the Face of the whole Earth; to receive their Impressions in full Measure, and comply with their Influences without any Restraint: But, the contrary, the Ocean being actually *confin'd* on all sides, by *unequal Shores* and *shoaly Bottoms*, to intercept its Motion, before it begins; and likewise to interrupt its Course, before it should end; *disordering its Undulations*, in irregular *To's* and *Fro's* all the way: I am to proportion my Measures accordingly: To make it plain, That, when all Circumstances are duly consider'd, the whole Diversity of the Tides, so caused throughout the World, is fairly accountable, and without much Difficulty deducible from the same Principles.

S E C T. I.

High-Water stated at the Interfection of the Equator, and the First Meridian; as being the Place least obnoxious to any Confinement, by Neighbouring Coasts, &c.

NOW, to pursue the strict Dependence of the Tide, especially upon the Moon under the aforesaid Confinement of the Sea, and speak more particularly upon that Subject as to Matter of Fact: I must fix the Center of my Observation and Discourse, on that Part of the Ocean, where the *First Meridian* crosses the *Equator*, at Right Angles; as most abstracting from the various Irregularities of Shells and Shores; or, That Great Meridian, which divides the *Atlantick* and *Ethiopick Ocean* jointly at the most equal Distance from those Three Parts of the World, which confine it; from *America*, on the West; and from *Europe*, and *Africk*, towards the East: (the Ocean lying open there, towards the North and South from the *Equator*, as far as the *Artick* and *Antarctic Polar Circles*;) To state aright the Flux, and Reflux of all the Tides, that either depend upon it, or have any Analogy to it, in other Places.

Having therefore firmly establish'd, in the precedent Discourse, that the Pressure of the Moon causeth the constant Motion of the Tide; Again, that her Pressure still increaseth till she reach the *Meridian* of any determin'd Place; and farther, that it is most intense

the Equator; and after all, I have shewn at
 that, that the Ocean, upon the said Point, is
 dispos'd to receive the Impression: Hence
 safely conclude (since as often as the
 is actually put, and Subject well dispos'd,
 Effect must necessarily follow;) That it is
 Water upon the said Point of Intersection,
 as the Moon arrives to that Meridian;
 is the Position to be prov'd.

Now, to reverse my Discourse, and argue
 the Effect to the Cause; it is constantly
 by Observation, that it is High-Water
 towards the Pole, (v. g. in our Northern Latitudes
 of England,) upon the said Meridian, when
 the Moon is also upon the same Line, at the
 same Time; and by consequence, the Ocean must
 be most depress'd there, to raise the Tide here
 in Result, from that Depression, as its proper
 Cause; since the Surface of the Sea cannot be
 in one Place, without an equal Depression
 elsewhere: So that, whether we argue from
 Cause to the Effect, or the Converse; the
 Conclusion is concluded as before, in the way of
 Reason: And our farther Recourse must be to
 Astronomers, and their Pilots for Instances, to
 confirm the same by plain Experience, and Matter
 of Fact.

§.

To establish this great and important Truth,
 we recourse to the Mariner's Observation for
 Matter of Fact; the Streight, wherein the Ex-
 periment is to be made, lying between Guiana
 in America, and Guinea in Africk; the English
 Colonies belonging to those Places, ought to be
 con-

consulted ; at what Hours, the Water flows on both Sides of it ; to gather thence *how*, when the middle Channel, more, or less, abounds with Water : And to begin with the *West-Indian Pilot's Account*, which is the most correct, and of quicker Dispatch : He informs that

‘ Before the *ſ. Cajana*, which lieth Five Degrees to the Northward of the Equator, about Twenty Degrees to the Westward of the Intersection aforeſaid, an East and West Moon makes High-Water there, on Change and Moon Days ; which is the only Instance he produceth of the Flood, within Eight Degrees of the Equinoctial Line, on that Side that can be concern'd in our present Enquiry.

But, to come up close to the Line, about Five Degrees nearer the ſaid Intersection, the Flood, as all Navigators observe, fills the Mouth of the *R. Amazonas* at $VI\frac{1}{4}$; or a Quarter later than the *ſ. Cajana* ; the Entrance of the former River being much larger, and full of Islands with Inlets, to take up more Time before they be full : And it cannot be doubted that the ſame Atlantick Flood, alike affected the *Braſilian Shore*, all along from thence to the *Roque*, (its utmoſt Eastern Point,) with the East and West Moon ; that is, at VI , or thereabouts.

And paſſing over the Streight, to the opposite Shore ; our *Guinean Pilot* preſently informs us ; First, ‘ That at River *Serbera*, upon the Edge of that Coast, the Water flows with the East and by South Moon ; that is, at $VI\frac{2}{3}$: (following the Shore to the Eastward,) and the Moon makes High-Water at *Swine*, at

a little farther, at *Gojawan*, a N. E. and East, and an E. N. East Moon, makes the ebb flow at $\text{III } \frac{2}{3}$, and at $\text{IV } \frac{1}{2}$: And passing along the same Coast to *Caran*, an East Moon ebbs there, at VI; as also an East and by North one, at $\text{VI } \frac{2}{3}$: At *Bening*, an Easterly Moon fills all full, at VI: And at *R. Rey*, an East Moon, and an East and by South does the ebb at VI, and $\text{VI } \frac{2}{3}$: At *Bato*, and *Camaroon*, an East, at VI: At *Monamba's Hole*, an East, and an East and by South Moon, at VI, and $\text{VI } \frac{2}{3}$: At *R. Danger*, an Easterly, about VI: And lastly, that at *R. Gabon*, upon the Equinoctial Line, an East and by N. makes the Flood, at VI; which includes all the rest, (one excepted) both for Time and Place, as will be shewn hereafter.

S E C T. II.

Reflections upon the precedent Account of the Tides, near the Equator, in the Channel between Guiana and Guinea.

Having already consulted both Reason, and Experience, about the Time of High-water, as far as both can assure Matter of Fact, upon the Coasts of *Guiana* and *Guinea*, and the Passage of the *Atlantick* and *Ethiopic* Seas, and their Intercourse between them: I am now to make some Reflections upon the pass'd Account, for the farther Elucidation, and Establishment of so important a Point; which sustains

sustains the whole Frame of my following Discourse upon that Subject.

First, It is observable, that *Six* of the *Thirteen* Places, which the *Pilot* for *Guinea* marks, have High-Water absolutely at *V* without any Variation: to wit, *Cajana*, *Suabening*, *Bato*, *Camaroon*, and *Danger*; which being so well agreed, and near an equal Number with all the rest, which are divided ought to render *that Hour* regular, and to be observ'd: Besides, *Four* of the Dissenters make but *Half-Tides* at different Times; as *Serbon*, *Caran*, *Rey*, and *Monamba*; which swell at *V* and withal at $\frac{1}{4}$ after; which plainly proceeds either from the *Unevenness* of their Shores, or the *shoaly Bottoms* which retard 'em: And as for *Two*, of those *Three* Dissenting Rivers; to wit, *Gabon*, and the *Amazones*, which are more positive in their Mistake, and remain unaccounted for; the *Former*, makes at *V* $\frac{2}{3}$; and the *Latter*, at *VI* $\frac{1}{4}$.

Whence it is to be noted, that at all the abovesaid *Thirteen* Places, (*Gojavan* excepted) the Sea is full, either *exactly* at *VI*, (their common *Standard*;) or within $\frac{1}{3}$ before *VI*, or $\frac{2}{3}$ after it.

A Difference so inconsiderable, and the Inequality of the Shores, which occasions it, is moderate; as to divert the depending Tide neither Way, from the *Rising* (and *Setting*) of the *Moon*, above *Forty Minutes*; for all that Trade of Sea, between *R. Gabon* and *F. Cajana*, from *East* to *West*, above *Twelve Hundred Leagues* yet at *Gojavan*, it floods at *III* $\frac{3}{4}$, and *IV* $\frac{1}{4}$, which is so preposterously early, and withal

disagree

freeable to its Fellows, that it merits an
 asional *Consideration* extraordinary; and
 as is by no means applicable to any of
 rest. Now

is observable, that, to heighten this Irre-
 rity, and withal to remove the Difficulty;
R. Swine, which lies next before it, flows
 isely at VI; and *Caran*, which follows
 after it, at $VI\frac{2}{3}$; their Shores being
 y equal, direct, and free from Shoals;
 et the Coasting Current, when it brings
 Tides along with it, pass smoothly by
 without any Impediment; whereas, on
 contrary, the *Mouth* of the *R. Gojavan*,
 ch gapes wide open to receive the Flood,
C. Palmas, which shoots it self *farthest* into
 Sea beyond all other, close behind it; and
 s the Coasting Current the most perem-
 y *Check*; and the first *Easterly* Turn, along
 Coast of *Guinea*, after it has left *Brasile*;
 backs the Flooding Stream into the River,
 a greatest Force and Precipitation; so as to
 all its Tumour, upon the first Appulse to
 Shore, by *Result*, so much *sooner* and *high-*
 as not to be supported any longer to the
 e Pitch, after the Energy of that first Push
 ver.

And the Flood, (as we are inform'd from the
 ervation of an Ingenious Friend,) makes as
 posterous Haste at *J. Cajana*, where it
 lls at IV; the Current driving it strongly,
 overhastily upon the Shore; yet, accord-
 to our *West-Indian Pilot's Account*, it is
 full, aloof off the Coast, till VI; where it
 continues Rising all the while, till it be at
 t Quarter-Ebb close at Land, where it swell'd
 highest

highest before : And the like happens at other Places, on the like Occasion ; as will be made appear hereafter, by many Examples : so that actually does that *most Irregular Tide* within the Compass of our Observation , contribute (when the Anomaly of *Currents* and *Shores* are adjusted) to our present Satisfaction. Here

It is farther observable, that the Flood pursues her Diurnal Course so close, as to arrive at no Two Places, of an *East* and *West* Position at once ; but one after another successively from *R. Gabon* to *J. Cajana* ; Flooding the *Meridians* all along respectively , at her *Rising* (and *Setting*) *Instants*.

Now, in regard the Ebb, keeps at the same *Six Hours* distance from the Flood , that the *Southing Moon* does from her *Rising* and *Setting* ; it must be *Ebb* at her *Southing* , when it was *Flood* at her *Rising* before ; through that Tract of Sea, with the same Order of Succession ; as well in the *Passage* aforesaid, as the *Intercourse* of the *Atlantick*, and *Ethiopian Oceans* ; and with the same Moon , that has been already remark'd upon the *Guianan*, and *Guinean Shores* ; from *R. Gabon* to *J. Cajana* for *Four Hours* Difference of Time, and *Two Hundred and Eighty Leagues* Distance of Place as aforesaid.

After all, since the joint Observation of the *Two Pilots* , co-extends to *Sixty Degrees* upon the *Equator* , and *Four Hours* upon the *Horizon* ; and affects both the *Land* and *Sea* , mix'd, of all sorts of Positions ; the Motion of the Tide being adjusted throughout to the *Diurnal Conduct* of the Moon ; the same Observation may, by Parity of Situation, be applied

to all other Seas and Shores around Our
e; whether they lie shut up by Land, as
Ethiopic and Indian Oceans are by the Gui-
and Arabian Shores, towards the North;
the Atlantick is by the Brasilian and Guia-
coasts, towards the South: Or else lie open
both Latitudes, as the *Pacifick Sea*, and the
both aforesaid, do towards North and South:
the Conclusion still holds, that *there must*
be Low-water upon the Line, wheresoever
the Moon is vertical; in case there be Sea-room,
towards the North, or South, or Both, to
a Tidal Impression.

Now, in regard the Tide by this Account,
thus Summ'd up, still *Flows*, on the said
section, at the *Moon's Rising*; it must con-
stantly do the like, upon the same Point, at
setting also; as being directly *Oppos'd* each
other, both in Time and Place: So it must
be at its *Lowest Ebb*, when she is advanc'd
to the said *Meridian*, as being the *Mean* between
Two *Extreams*; as also on the *Opposite* to
the other *Hemisphere*, for the same Reason;
upon all other *Meridians*, and *Parallels* be-
tween the *Tropicks*, upon her Approach to
Her Pressure constantly attending her
presence, in all Places, without exception:
forasmuch as every *Depression* between the
Poles, must raise a correspondent *Result* col-
lectively, towards the *Polar Circles*, upon the
same *Meridian*; it must respectively make
the *water at once*, in both North and South
Hemispheres, when she reacheth their *Meridians*,
there be Sea-room for that purpose. Let us
First, By Experience, that *there is actu-*
ally

ally such a Reciprocation of Tidal Turns in the Sea ; and shew, *Secondly*, By Reason of the Manner *How* it is really Effected.

S E C T. III.

How the Tide is stirr'd up by Pressure, and continued by Libration ; and whither it extends itself, before it makes its Returns.

HAVING found by Experience, that *Low-water* at the *Equator*, when the Moon is actually *Southing* upon the same *Meridian* Our *Northern Latitude* of *England*, as being *stoop'd* There by her Pressure, upon the Point of their Intersection ; and that, as the Tide is rais'd Here at her *Southing*, by Result ; so it needs be let fall again at her *Setting*, when her Presence is withdrawn which supports it ; so be set on, and taken off again *interchangeably* at every *Six Hours* End, by *Libration* : Annually, that the same *Six hourly Reciprocation*, (thro' the Analogy of *Their Seas* and *Flows* with *Ours*) be punctually observ'd all the *World* over : Hence it occurs to design its *Periodical Place*, as well as *Terms of Time*, both Here and Elsewhere ; and to shew *how* its *Librations* perform'd, and *how far* they are extended, both in Our *North Atlantick*, and in the other *Two Divisions* of the Ocean.

Now, to consult Reason, as well as Experience ; the *One End* of the *Tidal Balance* in the *Rise and Fall*, immediately upon the *Equator* where the Pressure of the Moon first feels

libration on Foot, both in Ours, and all the
as aforesaid: And the Other End is to be Ex-
tended as far as the Bottom of the Ocean (which
reverberates the Motion of its Results) directs
according to the Rules of Reflection: So that
the deeper the Bottom lies, the Tidal Tumour
must Result at a greater Distance from the
Place depress'd. Hence, its Depth being Un-
athomable, farther Recourse is to be had for
the said Distance, to Observation; which finds
the Flood to swell highest between 45 and 50
Degrees of both North and South Latitudes: So
that 24 or 25 Degrees (near the Tropicks) being
the Mean between those Two Extrems, to
wit, the Equator and the said Parallel of 45 or
50 Degrees of Latitude; it must be the Axe,
whereon the said Tidal Balance turns, to make
its Revolutions accordingly.

To begin (for best Acquaintance sake) with
the Search of the Atlantick Ocean; the Tide is
found to run highest, on the European side, on
the Coasts of France and Great Britain, between
45 and 55 Degrees of North Latitude; and on
the American Shore, it grows higher from Terra
Florida, along the Virginean Sea, and decays not
till it reacheth Davis Streights; but is conti-
nued even beyond 'em, by the favour of the
inclining Coasts: And altho' the Flood, which
is the Counterpart of its Libration in that Ocean,
near the Equator, exceeds not six or seven Foot
in Height; yet the vast Extent of its Compass,
makes it equivalent in Breadth; and able to
etch up the greatest Floods: For Example,
those at St. Malos, and Bristol: Whereas at
Virde, and the Opposite West-Indian Islands,
which lie under the Tropick, at 25 Degrees of
Latitude, which is their Common Axe; the
N same

same Tides, in passing it To and Fro, scarce make any Appearance at all; or even a sensible Variation of High and Low-water in the Ocean.

And to pass on to the *Ethiopick side* of the Line, we presently meet with a fierce and violent Flood, in the Chops of the Streight, between the Coasts of Guinea in *Africk*, and *Brazil* in *America*; which, being contracted on both Sides, by their Inclining Shores, even forceth Ships from their Anchors: And at the *Orbicular End* of that Flood's Libration, the Tide runs as high from *Rio de la Plato*, and *Terra del Fuego*, that is, from 40 to near 60 Degrees of Latitude as it does respectively on the Coast of *Europe*. Whereas at *St. Helen's Isle*, which intervenes at the *Axe of its Libration*, and lies at the same Latitude with *C. Virde*, on the Opposite side of the Line, it seldom exceeds a Foot; as is found by Observation.

And, to turn over to the Backside of *Pern*, we are often told of the high Floods which *Navigators* meet with in the *Pacifick Sea*, that set into the *West-End* of the *Magellanick Streight*, about 50 Degrees South Latitude: And again, we hear of the like in the *Gulph of Panama*, which lies within three Degrees of the *Equinoctial Line*; without the least mention of any Tide near the *Tropick*, that is Remarkable.

Finally, As to the said Libration in the *East-Indian Ocean* (which lies shut up towards the North), the Flux of the Tide, upon the Moon's Approach towards the *Meridian*, is constantly driven Sea-ward by her Pressure; as plainly appears, by the overhasty Return of its Reflux back again from the South, upon her Declination

on into the *West* ; not only to supply the *Vacuity*, left by her Absence ; but withal to fetch up Two of the *greatest Tides* that are known in those Parts, and Both in the *Torrid Zone* ; the One near the *Mouth of Indus*, and the Other of *Ganges* ; to the Wonder and *Astonishment* of the *Inhabitants* thereabouts : So manifest it is, that *Low-water* still attends her Presence and Pressure, *between the Tropicks* ; and *High-water* *Southward* as constantly with Her, *beyond 'em* ; and that Each succeeds the Other in both Places, by an *alternate Reciprocation*.

Such are the *Revolutions* of the *Tides* in those *Four Chief Divisions* of the *Ocean*, and manifestly they are perform'd by *Libration* ; with repeated *To's* and *Fro's* from the *Middle* of the *Torrid Zone*, down as far into the *Temperate Ones*, and back again ; as plainly appears by the *Instances* already produc'd for that purpose : Yet, forasmuch as those *Tidal Tumours*, either hang *pendulous* in the *Air* ; nor librate up and Down therein upon an *Axe*, which properly sustains 'em ; but *Raise* and *let Fall* each other, *Reciprocally* ; by the *Protrusion* and *Subtraction* of the same *Portion* of *Water* ; which follows the *Flood* close to supply and sustain it, till the *Ebb* withdraws it again ; and Both ways by *Flux*, and *Reflux*, alternately : Hence it occurs to shew, How such *Mountainous Billows* are translated *Backward* and *Forward*, with *Ease* and *Speed*, to so vast a *Distance*.

S E C T. IV.

The Collateral Result of the Tide's Undulations from between the Tropicks towards the Poles in six Hours ; and their Revolution back again in other six ; is shewn conformable to Reason and testified by Experience.

TO derive the *Tide's Undulations* (rais'd by the Dint of the Moon's Pressure upon the Sea, *between the Tropicks*), with a regular Course of Result from the Equator, into North and South Latitude : It is to be consider'd, that those Tidal Billows lie naturally extended East and West, from One side of the Ocean to the Other ; as being so directed by her Diurnal Course, which draws 'em Parallel to the Equator.

But withal, her Pressure being most Intense where it falls Perpendicularly upon the Surface of the Sea ; and she still holding on her Course between the Tropicks, or thereabouts the said Undulations must as constantly be driven transversely, from the intervening Impression towards the Polar Circles, by way of Result which, after the said Pressure is withdrawn must be devolv'd back again towards the Equator, by the Poise of their own Weight, according to the same Degrees whereby they were mounted ; the Moon, at their second Return still giving 'em a Counter-jog, to perpetuate their Reciprocation.

Now, in regard the Course of the Tide, as Navigators observe, runs very High into the North, as far as Davis Streight ; as also to the
Magella

Magellanick Gulph, which lies as far *South*; yet keeps Touch *both ways*, with the Moon's Impulse, which drives it Thither; it must needs perform its *To's* and *Fro's*, between the *Equator* and the *Artick* and *Antartick Circles*, backward and forward, in *Six Hours* apiece respectively; and Move each way 70 *Degrees* of Latitude, in *Six Hours* Space, at the rate of 230 *Leagues* per hour; which to do near the *Shore*, or in *Shallow Water*, were Impossible.

Yet, if we allow the *Expansion* of the Ocean to be of equal *Breadth* from *East* to *West*, with its *Length* from the *North* to the *South* (as the *North Part* of the *Atlantick*, for Example, is equally *Broad* from the Coast of *Africk*, to the bottom of the Bay of *Mexico*; as 'tis *Long* from the *Tropick of Cancer* to the *Artick Circle*;) The said Motion of the Tide, down the *Midst* of its Channel, will prove *smooth* and *easy* enough: or, if its *Area* were divided into *Square Inches*, no One of 'em needed, in all that *Six Hours* space to depart from its Fellow, either backward or forward, more than *twice its Breadth*, to perform its respective Part of the Revolution; so either to make their *Friction* difficult, or their *Sliding* by each other, even in the *Middle* stream, where their Motion wou'd be *swiftest*, all Perceptible.

Again, To allow the said Part of the *Atlantick*, a Profundity of *Depth*, proportionate to its Expansion in *Length*, and *Breadth*; the Water, so moved, must acquire a correspondent Volubility *Up* and *Down* to its *To's* and *Fro's*; and an equal Liberty to *Ascend*, or *Descend*, upon any Commotion, with more Ease; according to the Increase of the *Depth*, which

is occasion'd jointly, by its greater Distance from the *Shores* on each side, and from the *Bottom* of the Ocean; to Both which, the Water immoveably *Adheres*; so as to raise the *Highest* Flood, and let fall the *Lowest* Ebb, where the Channel is *Broadest*, and *Deepest*; as is manifest.

Now, seeing the Tide is Caused by *Pressure*, the Motion of its Gravitation must reach as far, as that part of the Stream, which is so depressed, *preponderates* the Dead-Water, which either *opposeth*, or *surrounds* it; That is to say, to the *Bottom* of the Sea, how Deep soever it be, before it *Rebound* up again to the same Height whence it descended: Again, forasmuch as it is driven *transversely* Both ways, from the *Pole* *perpendicular*; and deflects on each side of the *Equator*, alike towards *North* and *South* Latitude, it must fall upon the *Bottom* of the Sea, *Obliquely*; and be Reflected by it, at the *same* Angle *Upwards*, towards its Superficies: So that where the *Point of Repercussion* is deepest, the *Emergency* of the Tidal Tumour must be farthest off; and yet be perform'd alike, in *Six* Hours Space; and must reach its utmost Stretch, into our *North* Latitude, and as far into the *South* by the Force of the *same* Impulse, and at the *same* Time.

Yet the *Mid-Sea Current* of Water, how variable and far extended soever, needs not to Move, as to any determin'd Part, perhaps more than *Ten* or *Twelve* Feet, either Backward or Forward; since the Ocean is *continuous* throughout its Course, and the Tumour rais'd at the *One End* of it sufficeth to supply the Depression, whereby it was rais'd at the *Other*; and by

stances Fall below the Ocean's Level, to remount
 there a Tumour equal to it self; and so they
 stir up Each other reciprocally, by a Counter-
 vibration: As the Water in the One End of the
 Syphon, upon every Agitation, To and Fro, does
 the like in the Other End, at the same Time, by
 virtue of their Communication through the
 intermediate Tube which joins 'em, let their
 distance from Each other be what it will.

Besides, the *Spherical Curvity* of the Sea's Su-
 perficies, and the *Obliquity* of its *Declination*
 from the *Horizontal Plain* of the *Equator*, still
 meeting the Course of the *Ascending Arm*
 more directly, the *Angle of Intersection* is render'd
 more *Obtuse*: Again, its *Ascending Stream* be-
 ing, as it were, *alleviated* by *Reflection* up-
 wards, is Buoy'd up by the *Peristaltick Gravi-*
tation of the *surrounding Body* of *Dead-Water*;
 which still *Inclines* it, by degrees, *towards the*
perpendicular; till at last it affects the *supertending*
Arch of the *Ocean's Surface*, at *equal Angles* on
 every side; and raiseth a *Protuberance* upon
 it, without the *least determination* to any One
 part, more than the Rest: As the *Mariner* well
 observes, who finds no Tide in the *Middle* of
 the *Ocean*, to obstruct the Course of his *Ship*, or
 drive It one jot from its true *Longitude*, or
Latitude.

Nor needs the *Navigator* to complain, that
 the said *Protuberance* is any *hindrance* to his
 ship's way, while he surmounts it; which ri-
 seth not one Foot in a *hundred Leagues*; any more
 than a *Traveller* can repine at the *Unevenness* of
 his Journey, from *Edinburgh* to *London*, in case
 the *Oblateness* of the *Earth's Globe* raiseth the
 situation of the *Latter*, at least a *Fathom* higher

than the *Former*; Nor ought to discredit his *Own Observation*, as taken from a false or uncertain Level of the Sea, upon its *Tidal Tumour*, or *Detumescency*: A difference too small and nice, to be discern'd by the Bluntness of *Sense*, or discover'd by the Shortness of his *Instruments*.

So conformable is the *Result* of the *Tides Undulations* from the *Equator* towards the *Poles*, and their *Revolution* back again, both to the *Laws* of Motion, and *Testimony* of Experience, as well in the *Pacifick Ocean*, as in the *Atlantick*. Both which lie Open to the utmost *North* and *South*, without any Impediment; and no less in the *Indian* too, tho' it be quite shut up towards the *North*: In All which, as I have shewn in the *Last Section*, the *Tides* run very High in the *Torrid Zone*; and in *This*, that they mount to an equal or equivalent Height in the *Temperate*, as being the *Counterpoise* to Each other.

Yet, because the said *Extremes* must admit of a *Mean* between 'em, to be the *Axe* of their *Libration*; Hence it is farther observ'd, That whereas the *Tide*, on each side of the *Equator*, for the Space of about *twenty Degrees* on either hand, bears up to considerable Height; and from *forty Degrees* to *sixty*, reacheth the same Height, as being its *Counterpoise*: Yet, between *twenty* and *forty Degrees*, which is the *Axe* of their *Libration*, it grows scarce Perceptible; the *Tide* being upon a constant Decay, from the *Streight of Gibraltar*, till it revives again at the *Tropick*; and continues its *Increase* till it reacheth the *Equator*: But, from the Latitude of *sixty Degrees*, towards the *Poles*, as being the full Pe-

of its Course, on that side, it *Languisheth* a-
of its own Accord, insensibly to almost
ing ; every *Libration* consisting of *six*
and their *Reciprocation* of as many.

S E C T. V.

*The Circular Diffusion of the Tide, from the
Center of its Tumour, in Our North Atlan-
tic Ocean, to its Eastern and Western Shores ;
also towards the Tropick of Cancer, and
Artick Circle.*

Having already drawn the Course of the
Tide, from the Moon's *Depression* of the
upon the *Equator* ; and rais'd its Tumour
the Middle of Our *North Atlantick Sea*, by
Distention : Now, to enforce its Flood by its
efficiency, *Circularly*, towards all the
Parts of the Compass at once, by way of *Un-
dermining* ; No more is required, than what con-
stantly happens, upon the Fall of a *Stone* into
a Pool of Standing-Water ; which presently
beth forth *Circular Undulations*, after the
same Manner : But, before we proceed to de-
scribe it,

it is to be *Noted*, That the *Center* of the said
Tumour, cannot be affix'd, with a *Geometrical
Exactness*, to any *Point* or *Degree* of *Longitude*
or *Latitude*, till the *Depth* of the Sea (whereon
Angles of *Incidence* and *Reflection* depend) be
precisely known, as either the *Length*, or
Breadth thereof ; Nor can the *Space* of Sea af-
fected by it, be confin'd in a strict Sense, to
any

any determinate Compass upon its Surface as being effected by *too blunt* an Instrument; the Moon's Pressure is; Especially upon *bulky* a Body, as our *Globe* of Earth and conjoin'd; but must needs *spread* it self to a vast Extent, without any other Transference than its own proper Magnitude.

Besides, Our *North* Part of the *Atlantic* whereon this Tumour is rais'd, being of a Regular *Rectilinear Figure*; neither *Triangle* (which it most represents), nor a *Polygon* of any determinate Sort; and That Tumour which ought after a special manner to resemble It, consisting of *Water*, which must be *Curvilinearly* circumscribed, and yet be neither *Circular*, nor of any of the *Conick-Sections* cannot admit of any *Center*, in the strict Sense: Yet, because the *Lines* of its Diffusion must needs respect some *One Place*, more than the Rest; It will not be amiss, for *Illustration* sake, to assign some *One Place*, which may seem more proper than any *Other*; and how It will hit with *Experience* and *Observation*.

To assign the Point, as a *Center*, where That *Diffusion* of the Tide proceeds; it seems most Congruous, to fix It upon the *Great Meridian*; (I mean That, whereby Geographers discriminate the Two *Hemispheres* of the *Old* and *New World*, Each from Other), which serves to divide Our *North Atlantick*, with most equality, into *East* and *West* Parts: And where it is Intersected, by the *Parallel* of *Forty Degrees* of the same Latitude, as a *Mean* between the *Artick Pole*, and the *Equator*: Now to Evince at once, the *Existence* of such a Tumour

ur, whence the said *Diffusion* is *Actually*
; and that its *Center* is assign'd aright,
the *Setting* of the Tide every way Out-
from it, without any respect, or regard ;
duce the following *Instances*, for Examples ;
it is a generally receiv'd Opinion, and built
common Observation ; That, *the Tide sets,*
the Middle of all free and open Seas, directly
ads their Shores.

ow, to point out, in some measure, the
of its *Transfusion* in the *Atlantick* ; It
upon all the *Coasts of Europe*, out of the *West* :
to shew that it is not *afar off*, it arrives,
the *West Coast of Ireland*, as being the *Fore-*
of all *Europe*, at scarce *three Hours* after the
s *Southing*, upon *That Meridian* ; as it does
after, upon all the most *Western Coasts* of
e, *Spain*, and *Portugal*, which lie near the
Meridian ; without any regard to their
ent *Longitudes* : All which lie at near an
distance from the *Point* aforesaid, and make
-water at the *same Time* ; allowing only
few *Minutes*, to adjust the *Computation*,
proportion to the *Inequality* of their *Shores*.

ain, The *Course* of the Tide as little re-
s the *Longitude* of the *Places* which it af-
whether they lie *East* or *West* ; Provided
lie at an *equal distance* from the said *Me-*
; and have an *Open Sea* between 'em ;
ce the same Tide makes, at once, *High-*
er on the *Coast of New England*, in *America*,
on that of *Poitou* in *France*, and much af-
the same *Manner* ; As a *French Writer* re-
s it did, on *July 16th, 1670*, when there
open'd an *Extraordinary New Moon-Tide*,
the *Mouth* of the *River Pentequit*, in *New-*
England,

England, at *Eleven and a quarter* in the Morning; and at *Rochel* in France, about *Three and half* in the Afternoon; their Coasts, lying *seventy Degrees* distance; which adjusts the Tide almost to the *same Instant*, in both Places without any regard to the Diversity, of the *East and West Longitudes*, (the same Tide running *both Ways* at once;) or the least Notice taken of the Moon's *Absence* from both *Meridians*.

And as to the *flooding* of the Tide, directed towards *North and South*; seeing the Tide which happens between the *Tropick of Cancer* and the *Equator*, in the *South*; and the Tide which we here describe, swells up as its Counterpoise, between the said *Tropick*, and our *Pole*, in the *North*; it cannot terminate in the *same Instant*; but they must be *gradually discriminated*, each from the other, by a vast Space of the Ocean; which must be at once affected by all possible *Diversity* of *Heights* of Water, reciprocally: Hence that Interval must be holden to the *progressive Diffusion* of the aforesaid Tumour; to furnish it with a correspondent Tide, *setting into the South*, to what I have described, which flows towards the *East and West*.

Whence it comes to pass, that at the *Island of Teneriff*, which is the utmost *Westward* of the *Canaries*, and lies upon the *first Meridian*; it is not High-water, till the *Third Hour* after the Moon's Departure from it; because it lies at an *equal Distance*, from the *same Ebullition* of the Tide, with the *Western Coasts* of *Spain, Portugal, &c.* where it sets as aforesaid: And it sets out of the *North*, into the *South*, to

strate its Origin to be the same with theirs, h set from thence to the *East*, and *West*; and so sets all *Three Ways* at once, as is fest. And, by Parity of Reason, we must conclude, That the Tide sets like- from the same Center of its Diffusion, in- the North : as the *Dutch* find by Experience, sail back from their Northern Fishing by a Fortnight's Time, than they did er. And all Navigators Attest, that the er swells in *Forby's Passage* at VI ; in *Da- Streight* at VII $\frac{1}{2}$; and in *Baffin's Bay* at X; reffively towards the North, and in Spaces time, proportion'd to the Tracts of Sea h it passeth over, from the Center of its said Diffusion, to within fifteen Degrees of Pole it self.

ence it is as manifest, that That Diffusion he Tide, spreads itself circularly, from Middle of the *Atlantick* ; as that the *Sun's* flow from his resplendent Orb ; And the r of its Intumescency is as plainly re- d, by its setting outward every Way from as the Center of the *Sun* is, by the like sion of his Rays towards their Circum- East nce.

SECT.

S E C T. VI.

How the Tide is spread over the Atlantick Ocean, and communicates it self, to Other Seas, And by its alternate Floods, and Ebbs, makes Still a Restitution, correspondent to the Direction of its Motion.

TO devolve the tidal Tumour, rais'd by the Last Section, in the Center of the Atlantick, to all its surrounding Shores; no Force is required at present, than to let it sink down again, in the same Place, where it arose. Thereby to swell up, circularly, its Counters of Water, as far as the Compass of that Ocean can afford Depth, and Breadth, for its Subsidence to swell, and rowl in full Measure: the said Tumour being, of its own Nature, equally dispos'd alike; and the Sea equally dispos'd, on all Sides, to receive the Effect of its Undulation.

First, This circular Transfusion of the Tide expatiates it self farthest, in the shortest Time towards the North, (where the Ocean is of the largest Extent); meeting with no obstructing Shore, or Shallow, to countermand it from sinking again: And it Falls by Degrees, till the End of the Tumour's Impulse, which first set it on Foot, be quite spent, by so long a Continuance. As a Stone, cast into a Pool of standing Water, spreads its Undulations circularly; and lets the Waters fall still lower and lower, till the Common Surface languishing away by its Expansion, ceaseth to

ndly, As to the Tide's Transfusion to-
East, or West, where (the Ocean being
over; the Shore sooner occurs to the
ling Billow) upon its approach to the
ings, it presently stirs up its Flux that
And being straitned by the shallower
ms, into a less Compass, must seem to
more haste forward: As a River runs
and slow, while it continues wide and
but grows swifter upon its restraint, in
Respect: And where it finds a Creek,
et into the Land, it drives a stronger Cur-
hither-ward: And if the Mouth of the
which receives it, be wider Sea-ward,
row contracted afterwards, still its Speed
eased, in the same Proportion.

w, because Salt-Water, whereof this
effusive Tumour consists, is of a voluble
heavy Nature; it moves easily, after it is
set on Foot: And requires a proportio-
force, to stop its Career: And withal,
of too close and compact a Texture to
oppress'd; That Part of it which is actu-
ov'd, must still push on, that which goes
it, forward; so as to swell the Ebbing-
t, which occurs, into a Tumour, by Anti-
n; before the Flux of the Flood it self,
own proper Course, can possibly reach
a Pole, being thrust forward at the one
out an Inch, drives on the Motion of its
Length, at the same Instant, to the o-
tho' it be at least Ell-long: So may the
our of the Tide pass on a League, while
terminate Part of its Flood reaches above
long.

Hence

Hence it is, that our *English Channel*, having an open Mouth towards the Sea, receives the Flood freely; and having a proportionable Depth, lets its Tumour rowl forward, with great deal of Ease; and contracting it self afterwards in both Respects, keeps it up at the same Speed, till it reacheth the *Streight* between *Dover* and *Calais*; where it returns up the *Thames*, with some Abatement: But to the Sea-ward of *Holland* and *Denmark*, soon away to Nothing, by its greater Expansion. Thus every single Tide, as it was rais'd originally by *Protrusion*, so it is still carried forward by the projective Dint of its first Impulse, and the Moon's Depression of the Ocean near the *Equator*, all along the *Atlantick* up into the *Rivers*, where it expires.

Such is the progressive Flux of the Tide, from the first Depression of the Sea upon the *Equator*, to its result at the Center of the *Atlantic*; and it is thence convey'd thro' the *Northern Seas*, up into the *Rivers*, till its final Refluxion into *Calm-Water*: Now, in regard the Tumour, was not only refunded back to that Depression which first rais'd it, by way of *Restitution*, and fill'd up that Vacancy; but remounted it again to its own Height, by *Counter-Libration*; the like must be done to the Tumour, by the circular Billow, which rounded it; and, by Parity of Reason, the whole Progress of the tidal Flux thro' the *Oceans* and *Rivers*, requires a continual Regress and Reflux of the like Nature, in all Places.

And, since the Moon sets on her Prime at the *Equator*, and takes it off again, periodically, at every six Hours end; and correspondingly,

ently raiseth the *Atlantick* Tumour, and lets
fall again *as often*: The *secondary* Billow,
which is rais'd around it, must consequently
rise and fall reciprocally, by *counter-Libration*;
to receive and return its Quota's of Flood and
ebb, on all Sides of its Circle, at once respec-
tively, to make an alternate *Restitution* in the
Ocean: So must also the Floods and Ebbs, of
every dependant Sea, and River, become re-
ciprocally, and hit exactly the same Periods; as
appearing every where the double Stamp of their
first Commotion, impress'd upon 'em at the
Equator.

And, forasmuch as the Flood was rais'd at
first by the Moon's *Protrusive* Pressure; and the
ebbing-Water was let fall back again, alternate-
ly, by its own *Gravitation*, to fill up and sur-
mount the *Vacuity* left on the *Equator*; They
will retain every where, the same *Reciprocation*;
the Flood, by increasing progressively the *Ti-*
dal Tumour before it, by its *protractive* Addition;
and the Ebb, by withdrawing as much Water
behind it, by its *Gravitation*; leaving the Tu-
mour highest in the *Middle*, to maintain its
progressive Impulse, forward; while a *Sub-*
traction is made on the one Part, of what is
added on the other, to make a through-out *Re-*
stitution, with regard to the common Level of
the Ocean.

To make so general a *Restitution* with *Ease*
and *Expedition*; it is to be considered, That al-
though (for Example) the Flood which arrives
at *London-Bridge* was rais'd the Day before, by the
depression of the Sea at the *Equator*; yet ano-
ther Tide intervenes in the mean Time, between
those two Places, and happens every where alike

at *Twelve Hours* end, to supply the *Middle Stages*; and one Flood still succeeds another at the *same* distance of Time; as also an Ebb always intervenes between every *Two* Floods. Hence their *whole Course* of Ebbs and Floods naturally divides it self into *four Stages*, through which they pass with an *alternate Succession* but with a *different* Speed, and after a *diverse* Manner.

They run their *first Stage* from the *Equator* to the *Center* of our *Atlantick* in *Six Hours* space at the Rate of *five Hundred Leagues per Hour* (by way of *Libration*); and make their respective *Returns* in as many: The *second Stage*, from the said *Center* into the *Chops* of our *Channel*, in *Six* also, at the Rate of about *one Hundred Leagues per Hour*, (by *Undulation*;) The *Third* from their entrance into our *Channel*, to the *Streight* between *Dover* and *Calais*, (by *Fluctuation*,) only *Fifty Leagues per Hour*: And their *Last* from that *Streight* up the *River* of *Thames* (by a *protrusion* of *Fluxion*,) no more than *Ten*: And the *Highest* they go, the *less haste* they make to the final *Period* of their *Course*; till at last their *Pace* growing *so slow*, and their *Six Hours Allowance* for their *Interchange* continuing still *the same*; the *Tides* come up *so close*, one on the back of another, that *Two* are sometimes found at once within the *same River*: Thus, by a *perpetual Reciprocation*, every Flood having its succeeding Ebb to devolve it back again; each supplying its proportionate Part, in *due Order*; the Performance is every where at once render'd complete.

Lastly, Concerning the *Diffusion* of the *abovesaid Tumour* into the *South*; as much of it as tends directly towards that *Point* is soon pre-

to a Stop by the *Axe* of its *Libration* : But upon its Declination to the *Westward*, towards the *Cabbee* and *Antilla Islands*, this *secondary* Tide languisheth away almost into *Calm-Water* before it reacheth the *Primary* Flood, at so remote a distance from the *Center* of its Diffusion: Whereas to the *Eastward*, the Flood falling upon the Coast of *Africk* (which is not so far off) too obliquely to be repuls'd towards the *Northwest* Tumour, whence it came ; it is deflected into the *South*, and becomes a *Coasting Current* towards the *Equator* : And such like *Currents* attend the Shores of the *Indian*, *Ethiopick*, and *Pacifick Oceans* ; and doubtless, they proceed from the like Tumors : So that, having already discover'd their common *Origin*, let us see how they are propagated, in the following *Section*.

S E C T. VII.

How it comes to pass, that the *Coasting Currents* of the *Ocean*, which rise beyond the *Tropicks*, constantly tend towards the *Equator*.

THUS the Tide passeth from the *Equator*, beyond the *Tropicks*, and repasseth back again in the *Midst* of the *Ocean* in *Six Hours* piece, by an alternate *Libration* ; where it has free liberty to swell, and rowl at a greater Rate : But what correspondent Returns of Floods and Ebbs the *Coasting Currents*, which proceed from it, can make, by a *slow* *Progressive* Pace, upon their *shallow* and *narrow* Bottoms, is to be farther accounted for ; and their Courses are, in due proportion, to be adjusted to each other,

that every Flux may have its Reflux on either part, of the same Kind, or else some *Equivalent*, whereby to make the Ocean's *Equilibrium* by Restitution.

Now, in regard the Flux of these *Coasting Streams*, still descends from a Higher to a lower Situation; they must continually *withdraw* themselves from the *Flowing* towards the *Ebbing-Water*; as long as the Sea's Expansion, *betwixt* those Streams, is continued to an equal Breadth; and each Two counterpoising *Currents* (in compliance with the Floods and Ebbs, from whence they spring) must alternately rise *highest* and fall *lowest* at the said respective *Ends* of their *Libration*; but so (by reason of their *slow Pace*) as neither to raise nor lower the *Axe* of their *Mean Course*, from the *Level* of the Ocean: Their Fluxes and Refluxes *decaying* gradually into Calm Water, before they reach it; or else mutually so to affect each other, as to incline it *towards* neither Part.

But in case the *Gulphs*, on each Side where of there is an *Intercourse* of those counterpoising Streams, be *wider* at the one End than at the other; those Two Currents which proceed from the greater Expansion, being *contracted* by the *inclining Shores*, on both Sides, must become more and more enliven'd, to flow *Faster*, and hold out *longer* than those *other* on the Counterpart; which, being as much *dilated*, become proportionably *weaker*, and consequently *unable* to countermand 'em back again. In sum, much, that

1. The *Coasting Streams* of the *Ethiopic Ocean*, by receiving quicker Recruits of Water in the *South* (where the Sea is more *dilated*) by *Libration*

tion from the Flux of the Tide thitherward, which is perform'd in *Six Hours*; than can possibly be return'd by their *slow* Progressive Return towards the *Equator*, where it is most contracted; besides, sharp'ning their *Force* still more and more by their *Contraction*; they *repel* the *Counter-coasting* Streams, which otherwise would occur'd and met 'em the half way; and come, on both Accounts, *perpetual* without any *Reciprocation*.

And, forasmuch as the *Tidal Libration* is chiefly caused by the *Meridional Impulse* of the Moon's Pressure, driving it directly towards the *Poles*, by her Presence; and letting it fall back again perpendicularly, upon the *Equator*, in her Absence; the Motion of the said *Coasting* Streams as depending thereon, must so strictly serve the same Course; that, upon any *Deviation* from the true *North* and *South*, caused by the *Obliquity* of their Shores, they must still be sharpen'd into *quicker* Currents, on the inclining Sides; whether they be driven towards the *East* or *West*, or happen in *North* or *South Latitude*, without exception.

2. Hence we find, that the *Coasting Current* in our *North Atlantick*, tends as directly *Southward* towards the *Equator*, from the Streight of *Braltar*, along the Coast of *Gualata*, to *Cape Branco*, as the *Westerly* Inclination of the adjacent *African Shore* will permit; and keeps the incumbent *Trade-Wind* so close to the same *Southerly Direction*, as not to suffer it to exceed *twenty-Eight Degrees* to the *Norward*, tho' its usual Limit be *Thirty Degrees* at least; and being repuls'd by the *Shore of Guiana*, it enlargeth it self again to *Thirty Two* or *Thirty Three*:

Why Coasting-Currents

Which plainly demonstrates, that both the Sea and Wind are driven *athwart* their proper Course, or else the Flux of the *Former* had run true *South*; and the *Latter* had neither begun so near the *Equator*, nor had ended so far from it.

3. And to pass the *Line*, from the *Atlantic* to the *Ethiopick Ocean*, which lies extended *Pyramidically*, with its *Vertex* pointing into the *North* towards the *Equator*; and its *Basis* subtending it on the *South*, from the *Cape of Good Hope* as far as the *Magellanick Streight*; whence the *Collateral Currents* (which at first move but slowly thro' that vast Extent), being contracted by the *inclining Shores*, mend their Pace (especially on the *American Side*, where the Shore is more inclined to the *Eastward*) up to the *Equator*; and thence they pass *Two Degrees* farther till the *Tidal Tumour* out of the *North* comes up to countermand them; and then their united Stream veres about gradually, from *West* to *East*, and carries the *Trade-Wind* headlong with it, quite contrary to its Common Course, for *Five Hundred Leagues* together.

4. And when we double the said *Cape*, to the *Eastward* of the *African Coast*, we meet with a Current, which follows the Direction of the *Shore*, from *Madagascar*, *North-Easterly*, beyond the *Line*, into the *Arabian Gulph*, which conducts the *Southwest-Monsoon* thither; and being deflected by the *Cambaian Shore*, turns the *Northwest-Monsoon*, according to its Declination, back with it, into the more *Easterly Part* of the *Indian Ocean*; And to the *Eastward* of *China*, and *Cambodia*, we find the *North* and *South Floods* hastening, from the *Pacifick* and *Indian Oceans*, towards their Concourse at the *Equator*.

5. Finally

§. Finally, on the *Western-Shore* of *Peru*, a perpetual Flux of Stream follows the *Shore*, from beyond the *South Tropick* as far as the *Gulph of Panama*, up to the *Line* : (As also along the coast of *Africk*, from the *Cape of Good Hope* to the *South Shore* of *Guinea*) for near a *Thousand* leagues together : And, on the contrary, the ebb Flux of Water hasts to meet it there from the *North* at the same Rate, tho' with an unequal declivity of the *Shores* ; the *Wind* attending 'em respectively, upon the same Points ; which plainly shews, that the true *North* and *South* Points were chiefly aim'd at by 'em both ; and had been as strictly observ'd, had the proportion of their *Shores* prov'd more favourable to their Natural Inclination.

So general is the *Confluence* of all the *Coasting currents* of the Ocean, from all Sides towards the *Line* ; and so irresistible are their Courses thitherward, especially when their Channels grow more contracted that way : And to make as general a *Restitution* to those Seas, no more is required to keep their circular Correspondence on foot, than that, upon their arrival thither, they be ingulphed and swallowed down by the Detumescency of the Common Tide ; and be cast up again by its Intumescency, beyond the *Tropicks* whence they came ; that their Fluxes and Refluxes may be perpetually repeated, by an Alternate Reciprocation, for ever.

§.

Now, lest it may seem impossible, for the Tide to swell up Tumours upon the Ocean's Superficies, so high, as to let Streams fall down

from 'em, with a constant Descent, for Six, Seven, or Eight Hundred Leagues together ; and such as are the Currents which do Coast *Gualata*, and *Congo* in *Africk* ; and *Peru* in *America* : Or else, lest it shou'd appear no less practicable for any possible Impulse of the Sea to drive the said Stream progressively for so long a Course, upon the same Level with their adjacent Oceans, (which remain Calm and Stagnant all the while,) especially, their Channels being too Shallow and Narrow, for their Floods to be accelerated by Undulation or Libration ; as is manifest :

To clear these Doubts, it is remarkable ; that (all those Three Coasts lying open to the Ocean towards the West) the Trade Wind very opportunely supplies all those Defects, by descending down upon those Rills underneath, from their respective Eastern Shores ; which, by uniting its Streams of Air, with theirs of the Water, gives 'em Fall all along those Coasts ; especially the Wind moving also towards the Equator, where the Air is lighter, and more expanded to receive it.

And, as for those Currents that Coast the opposite Shores, which the Trade-Wind confronts on the East of *Brafile* and *Ethiopia*, after it hath gather'd more Force in passing over the East-Indian and West-Indian Oceans ; it is again remarkable, that it disputes every League of the Return of those Coasting Streams, towards the Equator ; and according to the several Seasons of the Year, takes their Advantage against each other's Courses, as well in the South Atlantick as the East-Indian Seas, while it blows on the South Side of the Line more Easterly, and on the North Side more Westerly ; but never to that degree,

tend towards the Equator.

77

e, as to put an absolute Stop to that of
sea underneath, towards the Equator.

d, if it appear less consistent with the
of Motion, than is practicable; that these
es from the Tide shou'd be *Periodical*, and
times *Intermit*; yet the dependent *Coasting*
ts flow *Progressively* the *same* way, to a
uity: 'Tis no more than what constantly
ens in the Flux of the *Veins*, in respect of
rteries, in the *Bodies* of *Animals*; and less
wonder'd at in these Currents of the *Sea*,
e fresh *Recruits* come in *Six-Hourly*, on the
art; and the Course which *evacuates* 'em
e other, reaches not its Period, with re-
o any *determinate Part* of the Water which
w'd, perhaps once in a Month.

h is the Tendency of these scatter'd
ns, in the *Ethiopick*, *Indian*, and *Pacifick*
; and so conformable to those, which
und in our *North Atlantick*; as to infer a
out *Analogy* in the Production, and Pro-
on of the Tide itself in *all Places*; so
least, as each of 'em to *swell up* a distinct
our, about *Forty-five Degrees* on each Side
e *Equator*; and to *diffuse* their *Effluvia*ms
the *same* manner, into *all Seas* and *Rivers*
out the *Universe*: Let us see how the
Bodies of the *Ethiopick* and *Atlantick* Floods
each other, at their *joint Return* to the
or; to draw the *Theory* of this Deduction,
a farther *Observation* of Matter of Fact.

SECT.

S E C T. VIII.

*Of the Concourse, and Result of the Ethiop
and Atlantick Tides, at the Equator ; and
Irregularities which attend 'em in the Straits
between Brasile and Guinea, Explain'd, and
concil'd.*

TO shut up my precedent Discourse of
Motions of the *Tide* and *Wind*, as they
precisely within the Precincts of the *Ocean* ;
as the Former takes its Rise from the *Moon's* in-
fluence, chiefly upon the *Equator* ; and returns
back again Thither from the *Poles*, in six Hours
piece ; It remains to determine *When*, and
those *Tides*, and *Winds*, which are peculiar to
the aforesaid *Oceans*, severally affect that Part
together with their respective Consequences
which are as follow.

First, Concerning the *Tide*, it is to be con-
sider'd ; That the *said Oceans*, consisting of
vast Bodies of Water, and lying Situate in
different Longitudes ; the Regulation of their re-
spective *Tides*, must be taken from their
Sea Tracts, where they Move with most Regu-
lar-
dom, and strictly observe the Course of the
Moon, whereon they depend : And, by con-
sequence, They cannot fall upon the *Equator*
at the Intersection of any *One determinate Meri-
dian*, nor be Regulated by it ; but Each
necessarily requires a *distinct One*, according to
their *different Longitudes* ; as is Manifest.

Besides, That part of the *Ocean*, which
more Easterly, must needs be so much sooner in-
fluenced, by the Diurnal Course of the *Moon*

its respective Tide, must precede the Other proportionably: Hence the *Ethiopick* Part, which lies more *Easterly* than the *Atlantick*, by thirty Degrees, must Flood about two Hours earlier, upon the *Equator*; and finding Low-Tide There, must pass beyond it to the North, all the while; until the *Atlantick* Tide comes up, to Countermand It; after it has transferr'd the *Line*, its proper Limit, at least four Degrees; as is found by Observation. Nor is any other *Parallel Line* assignable, for Opposite Floods, immediately to Insult each other; but rather their Counter-flux's must abate, at a considerable distance, and finally languish into a Calm, before they approach Each other; and jointly stagnate for a space of Sea, proportionate to their vast Extent. As Our North and South Tides do, at their Congress on the Coast of *Suffolk*, which they turn all along into a Pool: So do these counter-floods of the Ocean, stagnate near the Line into Calm-water, as *Hydrographers* remark, four to ten Degrees North Latitude; without Assigning for it, either This, or any Other Cause.

Yet the different Heights of the said becalm'd hours, so little correspond to the several Extent of the Floods, which respectively raise them; that, whereas Our North and South Channel well Humber, at their Congress, at least five Fathom; This, which is rais'd by the Congress of the said Oceans (taking the Tide at the same time, a Neighbouring Isle to the Line, for its standard) Ordinarily exceeds not six Foot, nor exceeds Extraordinarily above six Inches; in the Northward the *Ethiopick* Flood, having pass'd thro' the

the *Streight*, to the *Norward* of the *Equator*, proper Limit ; and *spent it self* by its Expansion, before their Congress ; it cannot advance its Stream higher : And afterwards (by its *Hours Ebb*, before the *Atlantick* makes Head water,) it *takes off* as much from the Flood that Tide, as it *Advanceth* ; and so keeps the joint Tumour to the same Height, without perceptible Addition, for near three Hours Space.

Moreover, in regard the said Tides, being driven Originally by the Moon's Pressure, at equal Angles from the *Equator*, True North and South ; they shou'd have recurr'd Perpendicular upon It, at their Congress : Yet (thro' the different Figure, as well as Situation of the Oceans,) They occur to Each other very obliquely ; the *Atlantick* Flood, being deflected Westward by the *African* Coast, from the *Streight of Gibraltar*, as far as *C. Verde* ; And the *Ethiopian* being contrary-wise devolv'd from the *Brazilian* Shore, to the Eastward, with greater Precipitation, upon the Tumour aforesaid ; which, running Eastward from the *First Meridian*, till at last it fetches the South Coast of *Guinea*, which deflects it Thitherward, for five hundred Leagues together.

Secondly, Touching the Winds, which in company the said Streams, neither Matter, nor Disposition for 'em, can be wanting in the Juncture ; the Air, throughout the *Torrid Zone*, being extremely *Rarify'd*, by the Heat of the Sun's Reflection, below ; and *Condens'd* as much by the excessive Cold of the Upper Region above ; as plainly appears, by the frequent and violent

nt Falling of *Hurricanes*, near the *Equator*; that also *Perpendicularly*; which are condensed into as Violent and impetuous a *Wind*; being only an *Horizontal Determination*; which They receive *Effectually* from the supping Streams of Salt-water; whose Current is *swift, perpetual*, and of a considerable

since the *Trade-wind*, which of Course is North-East from *C. Verde*, on the *Atlantic* side, and shou'd begin low, and increase gradually: On the contrary, it presently becomes Brisk; being enliven'd by the Breeze of the *Equatorial Current*, underneath; which deflects its course, according to the *Inclination* of that side, a Point or two more Norwardly; And it confines it to *Twenty-eight Degrees* of Latitude, instead of allowing it *Thirty Degrees*, its Usual stint: But afterwards, leaving the *Equator* off at Sea, lets the Wind fall again by degrees, before it reacheth the *Caribbees*: Both in observing the *In's* and *Out's* of the *American Shore*, and following the Conduct of the *Equatorial* Tendency, re-advance at last to *Twenty-two*, or *Thirty-three Degrees*, as it were rebound.

Thus the *Trade-Wind*, and the *Sea-Breeze*, each comply with Each other, for a Point or more in a *Calm* and expanded Ocean: But, to the contrary, on the *Ethiopick* side; where their courses are directly *Oppos'd* to each Other, the Wind must receive a stronger determination from the substrate Current; and so be inclined more to the *Eastward*, by the *Brasilian* Current; and re-enforc'd by that contracted Sea, to conserve and hasten their Motion; the Current

rent of *Water*, underneath, still drawing Incumbent *Air*, Forward; which, as it opening a Channel in the Sky, for That of Upper Region to rush down after it, Both push the Stream forward, by their Fall; still mutually exciting the other's Motion the Eastern Shore of *Ethiopia* at once stop to their joint Career.

Such is the Concourse of the *Ethiopick* and *Atlantick* Floods, both of Wind and Water, the Line: Now, to bring 'em off again by of Result, so that their Streams may makestitution to the Air's, and Sea's Equilibrium returning whence they came:

First, As to the Main Bodies of these Counter-Tides; as their Intumescency brought 'em on to their Congress, each in Space of six Hours; so the Detumescency of Floods, serves now to take 'em off again, backward and Forward, in equal Spaces of Time Counter-Libration; without making any motion in the Air, that is Progressive.

Secondly, As for those By-streams of Water which issue Progressively from 'em, and apt to produce the like Currents in the Air. They mutually propagate Each other, and jointly live, and die together; as happens in the Stream of *Water*, and *Wind* conjoin'd; *Wind* taking its Rise at *C. Verde*, and passing by *Guiana*, to the *Caribee-Islands*, conveys them thence around within the Bay of *Mexico*, they diffuse themselves again, from the Straights into the Ocean; where they separate into distinct Currents of Water, and Wind but are still of the same Westerly Determination.

and, as for That Stream of *Water*, and Flux
and, which makes so much haste through
said Streight, from the *West of Brasile*, to the
of *Guinea*; As to the *Watry part of it* (find-
no other Vent nor Retreat) it sinks Sea-
all the while; and parts with what's su-
perfluous, and exuberant, into the Ebbing
to carry it off by *Libration*; while the
incumbent *Wind*, which was dense and
before its Fall, goes on *Rarifying* again
Common Air, by the excessive Heat of the
till it be incorporated with the *South-
Trade-wind*, (and so 'tis return'd back a-
whence it came); which *never fails* to
at *two Degrees* on the *South* of the *E-*
; as receiving so constant a Supply; nor
There, as in *Other Seas*, from so steady
termination.

us are the Concourse and Result, of the
ick and *Atlantick Tides*, adjusted; foras-
as they consist of *Motion*: But, how
Occasion the Intervening *Calm*, requires
farther Explain'd, in the ensuing *Section*.

SECT. IX.

be *Calm in the said Streight*, is *Occasion'd*;
differs from those, which happen in other Seas.

Having already reconcil'd all Appearances
of *Irregularity*, in the Motions of Wind
de, which are apprehended to be in the
Streight, to the general Rules already pre-
sent'd 'em, by Those who have Treated on
that

that Subject : It may seem vain and superfluous, to search after Reasons for their Opposite *Calms*; since all Solid Bodies naturally rest; and Fluid ones too as constantly depend towards it, all Obstacles being Removed.

Yet, in regard a due *Examen* of One Contrary often serves to explain Another; and the restless Courses of the *Sun* and *Moon*, draw the Fluidity of *Air* and *Water*, into an endless Struggle of contrary Motions; and these volatile Elements lie so close together, that they can scarce be stirr'd, without disquieting the Other; *absolute Calms* can hardly be found either by *Sea* or *Land*; and even Those that are perceptible to *Sense*, are not so easily reduc'd to their proper Causes, as not to force Us to their *Existence*, *Continuance*, and *Extent*; we have recourse to their different Circumstances.

Concerning those *Calms*, which fall within the Compass of the *Trade-wind*; the Motion of the *Air* is every-where, both on Land and Sea, so various and inconstant, that no proper Seat, nor Sea, can be Assign'd for them. And more particularly, the Surface of the *Ocean* is so Obnoxious to be ruffl'd with a Blast of Wind, that no *Calm* can happen There, but by *Accident*; viz. that Both the *Flux*'s acquiesce at once; which can hardly be farther Accounted for: And, as to Those that happen between the *Tropicks*, they are seldom found in any *Open Sea*, where there is a constant Flux of Wind, or Water, to disturb their Tranquility; and that mostly, when the Course of the *Sun* is vertical; so as to raise the *Air*, and let it fall again Perpendicularly, in the same

So that those *Calms*, which fall, as it were, in *course*, and are remarkable for Time, or place; some are shelter'd in the *Bays* and *Reefs*, where they happen, by the adjacent *Mounts*, from all Commotions of either kind; *Air Heights* breaking those Blasts of Wind, and *Forelands* carrying off those Streams of Water *Seawards*, from one *Cape* to another, which wou'd otherwise disquiet 'em; as it cometh in that Elbow of the Sea, on the Coast of *Peru*, where *Calms* and *Hurricanes* are often found; the *Andes* sheltering 'em on the West, from the *Trade-wind*; and the *South* and *North* *Capes* keeping off the *Currents*, which pass by the interjacent *Bays* inoffensively, from one End of 'em to the other.

The like *Calms*, and *Hurricanes*, are found on the *South-East* Coast of *Africk*, in a Bay at the Entrance of the *Coasting-Current*, from the *Indian* Sea into the *Arabian Gulph*; which, according to the *South-west* Direction of its Channel, passeth along thither; while the *Isle of Madagascar* shelters it from the Insults of the *South-East Trade-Wind*; the like Harbour is found for 'em, on the *Eastern* Coast of *Coromandel*, when the *South-East Monsoon* ceaseth to disturb the *Gulph of Bengal*; and a long Range of Hills protects it on the *South-West* from the Tide, which is warded off all the while.

In other Seas, the Tranquility of the Air is secured from any irregular or hasty Commotion of the Tide, by the Constipation of many *Islands* pitch'd thick together, to hold their Superficies steady; as are those, on the *South-East* of *China*; which, being interspers'd

with the *Philippine* and *Molucca* Islands, are infested by *Hurricanes*, upon the breaking of the *Monsoons* into Calms, as to be scarcely navigable: As also the *Caribees* in the *West* where the Tides are weak; when the *North* *East* Trade-wind chanceth to cease, or intermit, are render'd almost uninhabitable.

Yet such furious *Storms*, which seem peculiar to these *Isles*, and so dreadfully afflict chiefly in *August*, when the Sun is vertical, are of no long Continuance, or great Extent, or Anniversary: Some Years having no more than one, and sometimes for several Years together, as *Dr. Halley* remarks, none at all. Whereas the Tract of Sea before-mentioned has no Trade-wind, nor a variable; but seems to be condemn'd to perpetual Calms, attended with terrible *Thunder* and *Lightning*; and frequent, as to be call'd *The Sea of Rains*; has neither any such adjoining Coast to shelter it; nor *Islands* to support its Quiet, as Calms require in other Seas.

But, as the joint Concurrence of the *Equatorial* and *Atlantick* Floods (as I have demonstrated in the last Section) conspire to bind that Tract of Water, fix'd; so their Concomitant Currents of Wind, suffice to foreclose all other contrary Motions, from annoying the Air's Tranquility, for all that Space: And I extend this Remark to the *Pacifick* also, where the *North* and *South* Tides have Sea-room enough, to insult each other at their Occurrence upon the *Equator*, all along from *India* to *China*, for two thousand Leagues together; yet they preserve the same Tranquility, both of Air, and Water, for four or five Degrees

each Side the *Line*; notwithstanding the Counter-
 approaches of the *South* and *North-East* Trade-
 winds, as *Hydrographers* describe, and *Naviga-*
 tors find by Experience; who, sailing *West-*
 ward from *Pera* to *China*, bear off their
 courses on each Side of the *Line*, at least six-
 Degrees, to take the said Winds at their
 Advantage.

It is manifest it is made, by the former Section
 Irregularities reconcil'd——, that the proper
 genuine Motion of the Tide, is true
 North and South, without any Deflection to-
 wards East, or West; save what's occasion'd
 by the Countering Coasts, or Channels, of a different
 direction: And that the *Eastern* Trade-wind
 is naturally bent to distract it, with all its
 North and North-easterly Variations; the for-
 mer depending chiefly on the *Meridional Pres-*
 sure of the *Moon*; and the latter on the *Air's*
Refraction, pursuant to the Diurnal Course of
 the *Sun*: And it is finally made remarkable,
 by this of Occasional Calms——, that those
 parts of Sea, wherein these Calms reside,
 where *Hurricanes* domineer, are only Elbows of
 the *Ocean*; or at least lie little obnoxious to
 Disturbance, from the two Motions of the
 Tide and Wind aforesaid.



C H A P. III.

*How the Tide is propagated, and spread
our Western Ocean; with special Regard
to Time and Place.*



SINCE I have hitherto only
sionally disclos'd the Nature of
Tide, and its Production; in
former Chapter, with regard
Time, and in the latter as to Pl
thro'out the Ocean; without insisting
on either of those Circumstances, than
draw the *Instances*, so remark'd, into one
tinued Series of Discourse, by way of
and *Effect*: In order to evince the Sun
Moon, to be the sole *efficient Causes* of
Tide; and their Pressure the *instru*
Means, whereby it is effected: And this
the Attestation of the daily *Experience*,
constant *Observation* of *Navigators*; as far
their *Senses* cou'd inform 'em, and their
express it.

But as to the *Manner*, how this great Work
perform'd, especially in our *Western Ocean*
which is best known to us; and why
propagated by *Libration* in the *Ethiopic*
and spread over the *Atlantick* by *Undula*
(which are caused alternately by their
sence, and *Absence*;) hence I design
Place where the Water makes, by the
mon *Lines of the Sphere*; and chiefly with

ard to the *New* and *Full-Moon* Tides, which
 intly observe the same Solar and Lunar
 ours, and are those whereon the rest de-
 nd.

And to express the Time, *when* the Water is
 affected; the *Horological* Characters I, V,
 are inserted in the *Squares* within the said
 es, to shew its Terms and Periods of Time;
 ile the *Darts* interspers'd among 'em, point
 their *Tendence*; and this also by a *Map*, to
 w their Distances, and Bearings, as to
 ce; that all may be render'd at one View,
 isible to the *Eye*, as it is perceptible by the
 nderstanding: And first, by a Draught of the
 in general; to shew the Natural Constitu-
 n of the Tide, in its greatest Amplitude;
 afterwards by more particular ones, to ex-
 t its Application to their several Divisions,
 r a more special Manner.

S E C T. I.

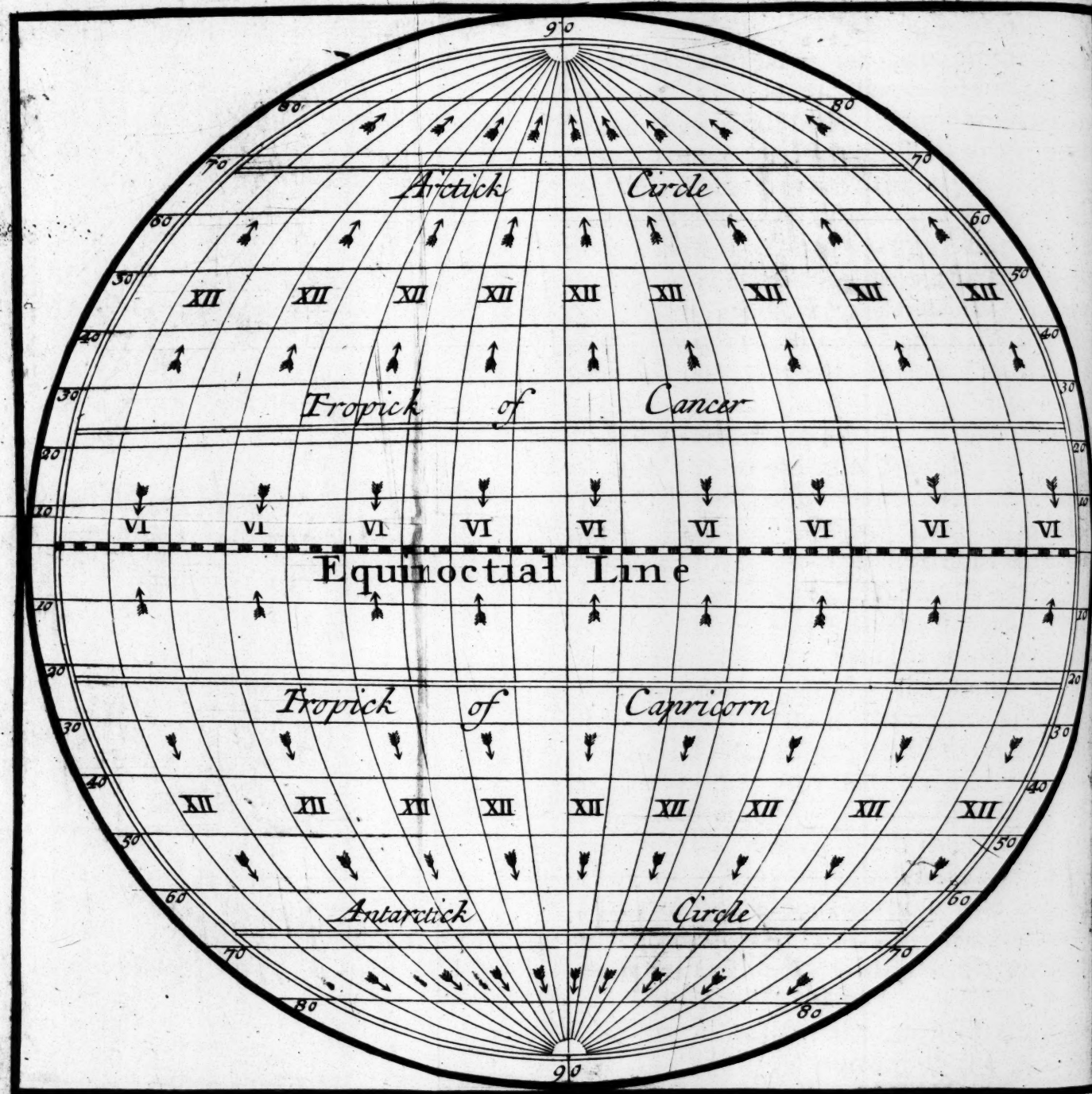
*The Application of the Tide to the Globe in Ge-
 eral; with regard to the principal Lines of
 the Sphere.*

Notwithstanding our Terrestrial Globe
 were universally surfac'd with Water;
 nevertheless, it wou'd stoop as low in the
 on's Presence, and rebound again as high
 er Absence, upon any determinate Point,
 een the Tropicks (where her Pressure is
 st intense) as it does at present: And con-
 quently, there must be High-water *where*

she Rises, and *when* she Sets upon the same Place, as lying at the farthest Horizontal-Distance East and West, from her Culmination Point: Hence the Figures VI^s, are placed upon the Equator, and properly belong to that Space of Sea, *between the Tropicks*, to note the Hour of High-water, not only upon the Lines whereto they are affixed; but also on all the respective Meridians, within the said Space, successively from East to West, pursuant to her Diurnal Motion around the Earth.

And, forasmuch as where the Moon culminates, between the Tropicks, is made the deepest Depression; from whence results the highest Tumour, beyond 'em; as it were Rebound, from the one Extream of Depth, to the other of Height, by the shortest and directest Lines; and with the greatest Force, and Expedition possible: And the Tumour so raised must fall back again by the same Path, into the Vacuity whence it came; to advance no farther in the same Place, to near an equal Height with the best Advantage; and so alternate raise each other by Counter-Libration, on each Side of the Tropicks, upon the same Meridians. Hence the XII^s, which denote the Time, and Place of the Floods without the Tropicks, are placed upon the same Meridional Lines (with their respective VI^s within 'em) upon the Parallels proper for them.

Now, in regard the Angle of the Pressure Incidence upon the Bottom of the Sea, whereon it falls; and of the Flood's Emergency from it, are the same; and the Axe of their Libration must be Equidistant from 'em both: Sit



The *Axes* of the Tides, on each Side of the Equator, are found by Experience to be the Tropicks; and these, lie about *twenty-three Degrees* distant from it: Hence the XII^s; with the Tropicks, are affix'd at double the Distance of *twenty three Degrees* from that Line, the Parallels of *forty-five Degrees* in both latitudes; to correspond to each other in that Distance, and still continue upon the same Meridians, with their respective Equinoctial VI^s; which are the Lines of the Tide's Limitation, and change successively every Moment, according to the Diurnal Course of the Moon; hence those XII^s, and these VI^s are described; those on their Parallels and these on the Equator, around the Globe, at equal spaces; to express the Diurnal Succession of High and Low-water, from one Meridian to another, for ever.

Moreover the said *Axes*, whereon the Tidal variation alternately revolves, suffering no such Protuberance themselves; and lying extended directly from East to West, leave the use of the Water a free Liberty, to sway rising Tumours, according to their own inclination, indifferently either towards North, or South: Hence the Darts, in the bordering squares, still point forwards the same Way; direct their Settings perpendicularly, either towards the VI^s, inscribed on the Equator; or towards the XII^s, upon the Parallels aforesaid; which is as far, as the Activity of the said Limitation properly extends.

Finally, the two Ranks of Darts, which are placed beyond the said Parallels, on both sides of the Polar Circles, still direct the Setting

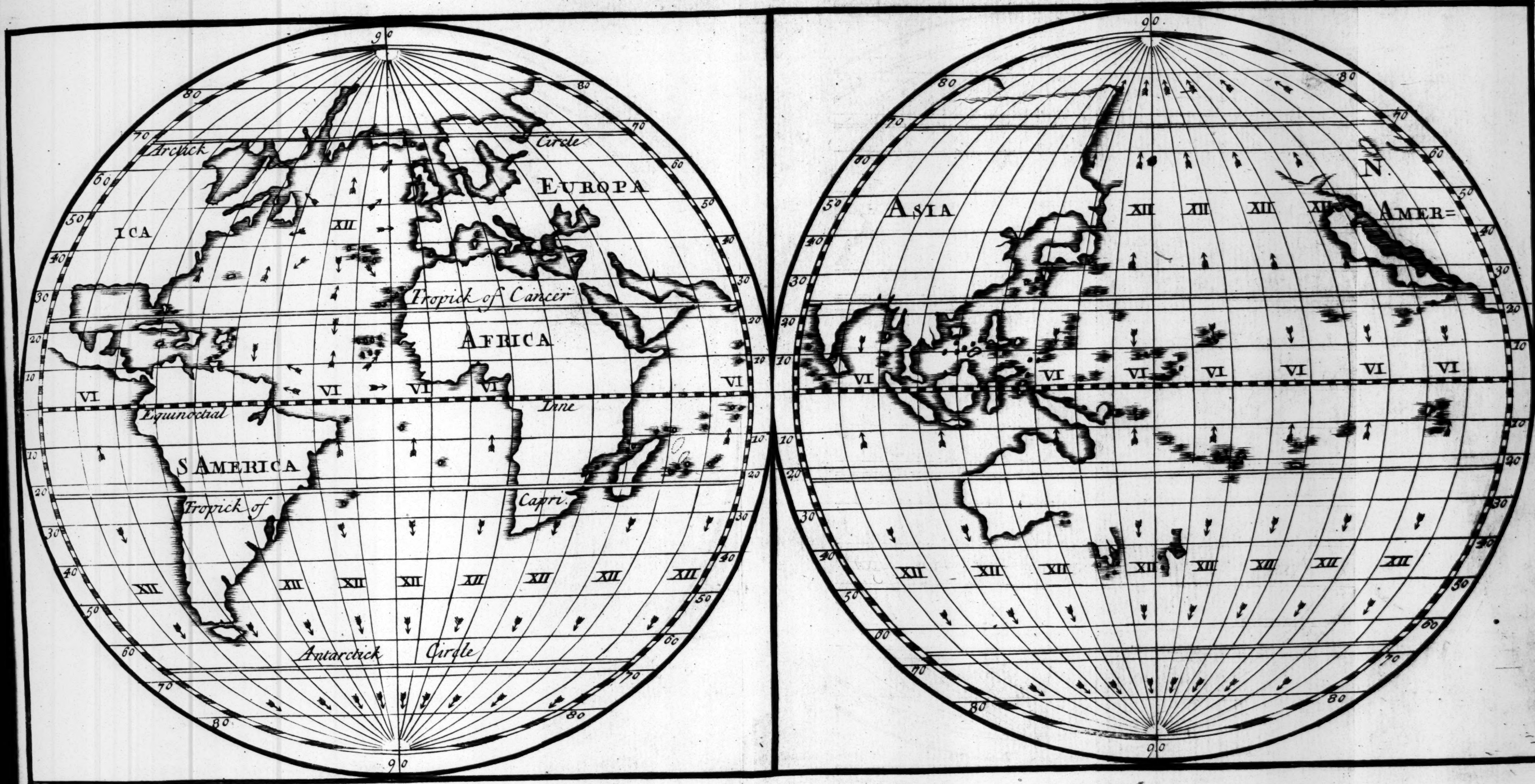
ting of the Tides to the *Norward*: which being propagated by *Undulation*, make no remarkable Returns; their wavy Billows, either reaching the *Poles* themselves; or else *subsiding* at last into smooth Water, suppress'd by their own Weight.

Such is the *Theory* of the *Course*, and Constitution of the Tide, as described by the *Lines* of the *Sphere*, upon a *boundless* Ocean. Now, to apply the same to practice upon the *Sea*, as it lies actually *confined* by the *Coasts*, and *Shores*, of our terraqueous *Globe*; that which *Speculation* has already propos'd in general, is most agreeable to Reason, may be found by *Experience*, to be Matter of Fact; in the *Places* most concern'd, thro'out the *Universe*.
I begin with the Display

S E C T. II.

Of the Tide's Application to our Western Ocean with a special Regard to the Ethiopick Division.

TO descend from the Consideration of the *Sea in general*; to the farther Inspection of our *Western Ocean*, in particular with reference to the Tide's Reception, it is extended from the *Artick*, to the *Antartick Polar-Circle*; divided into *two Seas*, with an open and free Passage betwixt 'em, for the intercourse of its Floods out of both *Northern* and *South* Latitudes: And to enter, in the *Place*



ce, upon the Survey of the *Ethiopick* Part, the Figure is pretty *Regular*, and Situation is *Oriental*; it is observable, that its *Eastern* Side lies *North* and *South*, from near the Mouth of *Benin*, to the *Cape of Good Hope*, for *180 Degrees* together; to give the *Morning* and its proper *Direction*:

And withal, to serve for a *Pattern*, to draw more *Westerly* Lines of the Tide's *Libration*, Parallel to itself; and with a singular *Conformity* amongst themselves (conformable to that which is already described in the general *Map of the Globe*); and so close to each other, thro'out that Sea, to the *Eastern Coast of Brasil*; as to carry the *Succeſſion* of the Tides, thitherward, Line by Line, concomitantly to the *Diurnal Motion* of the Moon, in her *Rising* towards her *Setting*; as far as the *Breadth* of that Sea extends; while the *West Coast of Guinea*, which stretcheth itself Eastward from *East* to *West*, along the *Northern* Side of this Sea's Division, serves for a *Scale*, to mark the *Hours* and *Minutes* of their *Conſtancy*, for *five hundred Leagues* to the *Eastward*: Let us consult the *Pilot's Observation*, in this Point; and take his Word, illustrated with a *Map* that's drawn according to the *own Direction*, for an undeniable *Prin-*

to begin the said *Series* of *Floods*, at the *farthest* Part of the *Gulph*, the *English Pilot* of *Guinea*, assures Us; "That at *R. Gabon*, on the *Equinoctial Line*, an *East* and by *North* Moon makes *High-water*, at $V\frac{1}{2}$; and at *R. Danger*, an *Easterly* does the same, " about

" about VI: At *Monamba's Hole*, an *E*
 " and an *East* by *S. Moon*, at VI, and VI
 " At *Bato*, and *Camaroon*, an *East*, at VI:
 " at *R. Rey*, does an *East*, and an *East*
 " *South Moon*, at VI, and $VI\frac{2}{3}$; At *Be*
 " an *Easterly Moon* fills all full, at VI;
 " at *Caran*, an *East*, and *East* by *S.* one,
 " VI, and $VI\frac{2}{3}$; and passing along the
 " Coast to *Gojaven*, a *North-East* by *E.*
 " an *East N. E. Moon* makes the *Water*
 " there, at $III\frac{2}{3}$, and $IV\frac{1}{3}$: And a little
 " ther at *Swine*, an *E. Moon* swells the
 " ter, at VI: And following the *Shore*
 " the utmost *West*, at *R. Serbera*, the *W*
 " flows with an *East* by *South Moon*, at VI
 So close does the *Westward Motion* of
 Tide, stick to her *Diurnal Course* all the way
 for five hundred Leagues together.

Now, to demonstrate that the Tide
 flows her said Course, to the *Westward*
 close, both for *Succession* of Time, and Height
 of Water, and flows as constantly at XII,
 on the Parallel of 45 Deg. S. Latitude; as
 doth upon the *Equator* near VI, along
 Coast of *Guinea*.

First, As to the Account of Time; the
 ter flows, on Change-days, at *Port Desir*,
 27 Deg. S. Latitude, upon the *West Amer*
Shore, exactly at XII, the Moon being *ve*
cal; and, *Secondly*, As for Height of Flood
 51 Deg. S. Latitude, it is not wanting in
R. Gallegos, upon the same Shore, (which
 riseth and falleth 60 Feet) to equalize our
 the *Western Coasts* of *Europe*, at the same
 of N. Latitude: Without the Concurrence
 the inclining Shores, and shallow Bottoms,

NORTH

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ent in our *narrow Seas*; and so may
for a *Standard* both of Time and Tide,
the said *American Shores*, from 47 Deg.
Deg. S. Latitude, that is, from C. *Blan-*
C. Horn; the various Ins an Outs of the
Declivity, being consider'd.

And if it be *objected*, that, in the Mouth of
Magellanick Streight (which lies but one
ee from that *River*, and scarce 4 Deg.
the said *Port*) the Flood riseth not *half*
as at the one, and yet makes High-water
by an *Hour*, than at the other: It is re-
that the Streight is flooded there *irregu-*
in both respects: For,

As to the *former*, viz. That it riseth
Fathom instead of 10, as in the said
; the Bay, which is the *Entrance* into
id Streight, *contracting* its Sides towards
ottom, into a *narrow Gullet*, opens itself
into a *second Bay*, of an equal Extent:
e the Flood, by its passing thro' it out of
e into the other, *loseth* half of its Height
e former; and *repassing* it, keeps up its
s much, by way of *Restitution*; especial-
ng swell'd by the *Occourse* of the Streight's
y Current, from the *East*; the Tide of
and Ebb, running *so strong both ways*,
ately, as not to be stemm'd; tho' scarce
discern'd in the *Streight's Mouth*, which
s fix'd all the while, within the Com-
of 4 *Fathom*; as being the *Mean* betwixt
wo *Gallego's* Extremes, which it never
eth.

y, Forasmuch as the *Streight* receives the
in ample Manner, with an *open Bay*,
h is rais'd proportionatly with its Stream,
which

which goes on *decaying* 'till High-water. Whereas its Current, being *straitned* by said Gullet, goes *encreasing* all the while; the latter must needs take off the *Top* of the former, at least *an Hour* sooner than ordinary. Hence it comes to pass; that, as the Tide in *Streight's Mouth*, neither swell'd so high, nor sunk so low as in the *River Gallegos*; and withal surceaseth to rise, before it does for *Port Desire*; yet, at all three Places, the Tidal Supplies were added and withdrawn, the same respective *Instants*, and also in equal Measure.

After all, since the abovesaid Tide at *Gabon* neither issued out of the *East*, whence the *Sea* nor *Gulph* could be found to supply it; nor was it brought along by the Current from the *Westward*, which directly *opposed* its Course; much less was it favour'd by the *Atlantic* Flood out of the *North*, which bore strongly *against* it; but was wholly supplied by the *Ethiopick* Tract of Sea, which is open to the *South*. And in regard the Tide between the Latitude of *Port Desire*, and the *River Gallegos*, most abounds with Water, at XII, when the Tide at *Gabon* wants it VI, and on the *Converse*; hence the one must needs supply the other; and both Tracts must be equally co-extended *East* and *West* to do it *successively*, according to the *Diurnal* Conduct of the Moon, already described.

And their mutual Correspondence is kept on Foot by *Libration*; as plainly appears in the *Counterpoising* Tumours, at each End of the *Ballance*; the one near the *Magellanic* Streight, which is vast for Height; and the other

er upon the said South-Guinean Coast, which is as formidable for *Speed* and *Force*: while at *St. Helen's*, near its *Axe*, the Surface of the Water riseth or falleth scarce a Foot: which furnishing the other with new Recruits of Stream, and fetching 'em off again alternately, without Intermiſſion.

Thus the Tidal Tumour swells with the rising Moon, and sinks again in the Ethiopick Part of Sea, with her Southing Pressure upon the Equator; and the Lines of its alternate Approach thereto, and Recess from it, lying parallel to the Eastern Coast (which gave 'em their first Direction) fall Perpendicularly upon that Line, with the same Uniformity, that I have already described, in the Universal Map of the Globe; while the Moon, pursuant to

Diurnal Motion from East to West, successively depresseth the Water's Superficies, within the Tropicks; to raise it again by Lifting, beyond 'em, at the very same Instant; so that what she expels by her Pressure, from one Side; may be fetch'd back again from the other, by its own Weight, with an alternate reciprocation.

So fitly, in every respect, doth the regular Appearance of the Ethiopick Flood, fall (for an Example) to establish the Preliminary Account already given of it, in the Description of the Sphere in general; nor will the manifold Anomaly of the Atlantick Tides, when duly consider'd, more prejudice the Validity of that General Rule, by way of Exception; than the Conditional Proviso's, do the Obligation of a Bond; but, on the contrary,

trary, serve both to explain, and enforce
Let us try the Experiment.

S E C T. III.

*Why the Atlantick Flood is not devolv'd diu-
to the Westward, like the Ethiopick;
makes full Sea from East to West, at the
Instant.*

WHEREAS the Lines of the Tide's
bration, lie so uniformly extend-
North and South, on the *Ethiopick* Side of the
Equinoctial Line, as I have declared, to give
its Floods, and Ebbs, a suitable *Reciprocity*
on the contrary, the *Atlantick* Division of the
Western Ocean, being neither of a *Rectilineal*
Figure, to give 'em any special Direction
nor of a regular Shape, to conform 'em suitable
each to other; all the said Lines, are con-
fusedly involv'd into one; and that also, be-
comes as variously deflected either to the East
or Westward, according to the Declivity of
its Shores; *Cape Verde*, and its adjacent Islands
giving that *Atlantick* Flood, at its first Ap-
pearance, a *Westerly* Turn towards the *Cape*
Verdes, for at least twenty Degrees; which it
Coasts of *Florida*, *Virginia*, &c. up to the
found Land, as briskly return full thirty Degrees
again to the *Eastward*; and it is still devolv'd
from both Sides, into the *Middle Channel*, where
it rowls with most Freedom, and must flow
all at once, as it were, with one single Mo-
tion.

Be-
fide

Besides, the Bluntness of the *Moon's Atmosphere*, universally affecting the *whole Surface* of that *Atlantick Tract* of Sea, between *Tropicks* (as it were a *Lake*), without any considerable difference of Pressure; the pious Self-coherence of the Water, so general-affected at once, cannot successively resent the pressure, with any sensible *Distinction*; and consequently its Superficies must fall or rise *everywhere*, co-extensively from *East and West*; in the *African*, to the *American Shore*; is, from the *one End* of its *Tidal Axe*, to the *other*; as it plainly appears to do, by *Mat- of Fact*. For,

At *Cape Bajador*, at the *East End* of it, on the *African Side*; the Water flows with a *full Moon*, exactly at *XII*; so also at *Carolina*, on the *West*, on the opposite *American Coast*, it ebbs with an *E. S. E. Moon*, at *VII½*; being distant from each other *seventy Degrees* in *Longitude*; which corresponds to *four Hours* and a *half* of Time, upon the *Horoscope*; which being added to *VII½*, makes the Number *XII* compleat, for the Water to flow, at two so far distant Places, just at the same moment.

Again, Since the said *Librative Motion* necessarily requires, that the counterposing Arms of *Balance*, be dispos'd jointly the one to *ascend*, the other to *descend* at the same Instant; consequently each of 'em, according to its *own* and every Part, at whatever Distance from the *Axe*, must attain at once to its utmost *Height*, or *Depth* respectively: So must the *Atlantick Tide* acquire its *Summits* of Flood, and *ebb*, at the same Time, at all Distances of

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Latitude from its *Northern Tropick*, to forty Degrees of Latitude; and as far towards the *East* and *West*, as its *Libration* extends: As it actually happens, at *Gay-Head* in *New-England*, where the Moon, at S. E. by E. make High water at VIII $\frac{1}{4}$; being distant from *Carolina* fifteen Degrees N. Latitude, and about eleven Degrees in Longitude, which corresponds to an Hour; which, being added to the VII $\frac{1}{2}$ at *Carolina*, adjusts the Account of the Tide at *Gay-Head*, at VIII $\frac{1}{2}$, to an *Instant*; without any Consideration had to the Distance in Latitude at all.

Moreover, forasmuch as the Moon's Position, affects the whole Space of the *Atlantic* between the *Equator* and the *Tropick*, consistently from *South* to *North*, as well as from *East* to *West*; and with that Conformity, to raise the Tide by *Contraposition*, at all the three Places above-mentioned, at the same Instant, tho' at so great a Distance from each other, both for Longitude, and Latitude. Hence the Tide so rais'd, to answer the Position's Extension, must affect, with the same Regularity in every respect, not only the distant Places, and the Lines of Distance between 'em; but also the Area design'd thereby, and contain'd therein: That is, the whole Body of the said Water, between the *Tropick*, and the Parallel of forty five; from the *African Shore* to the *American Coast*, so swell it all at once, according to its whole Extent.

And, if it be objected; That a Solar Moon makes a regular Tide, upon the Coast of the *Atlantick*, at XII; as being distant

interposed to her Noon-stead Pressure, between the Tropicks, at VI; an Hour later, in at the three Places above-mentioned; as appears by the Tide at C. Bajador, which also makes with a Southing Moon, fifteen Degrees more to the Eastward, an Hour sooner than it; and consequently so much sooner than its other two contemporary Floods at Carolina, and Gay-Head: It is reply'd, that the Tidal humour is rais'd over-hastily, at all those three Places at once, by a preposterous Check: First, at C. Bajador, by the inclining Shores of the Canary Islands, compressing its Stream on the one Side, and of the Continent, on the other: The like is done by the Carolina Coast, in Opposition to the Babamean Bank; which, being wide to receive the Stream, contracts to a Point in the Mouth of the Gulph of Florida; whose Current drives the Flood with so much Precipitation against the Shore, that it makes at VII $\frac{1}{2}$ a full Hour sooner, than in the R. tho' upon the same Coast, and not above two Degrees distant from it. Lastly, the promontory of Gay-Head (as C. Palmas at the Entrance of the R. Gojaven) hasteneth the Flood as much sooner, than it makes in the Arabian Sea, whence it sets; or, than in the Gulph along New-England, which receives it. So exact is the Conformity of the said Primary Tides, with each other, between the Tropick and the Parallel aforesaid; and (abstracting from the Impediments of Coasts and Rivers) with the Central XII, which, in the middle of the Atlantick, has free Liberty to swell and sink at regular Hours, without any disorder; and so well prepar'd is the Plan of

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that

that Tract of Sea, for a *secondary* Sort to be rais'd upon it. Let us see with what Account it is effected.

S E C T. IV.

Concerning the Circular Transfusion of the Secondary Tide; and, how it corresponds with the Libration of the Primary one.

NOtwithstanding the Co-extension of the Moon's Pressure, to all that Tract of the *Atlantick* already described; so as to adjust the *Primary Tide* to itself, thro'out the full Extent of Sea, to the *same Instant*, from the very Nature of its *Libration*; yet, as to the Part of the same Tidal Wave, which keeps closest to the Sea's *Central Meridian*, where it flows in *deepest* Water, and flows in the *directest* Channel, from the *Tropick*, its supposed *Axe*, towards the *Pole*; it must needs run higher than the rest of the Ocean: And the farther this Flood passeth beyond its *Axe*, the more it must be *advanced*, even to the Summit of its Lift, at the Parallel of *forty-five Degrees* Latitude; at an equal Distance from the *Equator*, whence it was forced: And now upon its Return thither, it *sinks* again, being depress'd by its own *Weight*; and raiseth round its *Apex*, by *Result*, (as a Stone let fall into a *Lake*) a *Secondary Tumour*; which diffusetb itself *Circularly* by *Undulation*.

Now, to describe the *Circular Diffusion* of this *Secondary Tide*, in reference to the Time and Place of the *Primary Sort*; the one Foot of the *Compass* is to be set upon the Point, which

mark'd in the *Map* with XII ; where the
 Central Meridian of the said Sea, intersects
 Parallel of forty-five Degrees Latitude,
 whence its *Transfusion* is made : And the other
 be extended *Eastward*, to the Promonto-
 ry of *Europe* ; as for Instance, to C. *Finister*
Spain ; and turn'd thence *Westward*, to the
 Shores of *America*, to *Manomy Point* in *New-*
England : Whence it will plainly appear ;
 their opposite Shores lie at about sixty De-
 grees of Longitude from each other, as to
 the Moon ; and allowing the Diurnal Course of
 the Moon fifteen Degrees, for an Hour, they
 are at four Hours Distance, of Time ; which is
 accounted the Diameter of its Circuit,
 whereof its Activity, within the interja-
 ctory Ocean.

And, forasmuch as the Moon cannot reach
 the said Central Meridian, to make High-water
 at Central Noon-stead XII, 'till she has
 run the European Promontories thirty De-
 grees, or two Hours, after her Southing at
Finister : And passing forward fifteen Degrees
 more, to the Westward of the said Meridian,
 she has High-water at the third Hour after her
 Southing at the Places aforesaid ; that is to
 say at III in the Afternoon ; according to
 Observation : Hence it is manifest, that while
 she advances forward Westwardly, fifteen Degrees,
 in one Hour, upon the *Horoscope* ; the Tide
 sets itself back again to the Eastward, thir-
 ty Degrees upon the *Globe*, as far as C. *Finister*.
 Now, in regard *Monomy Point* lies to the
 Westward of the said Central Line, as C. *Finister*
 to the Eastward thereof ; and both at
 thirty Degrees, in Longitude, distance from it ;

So that the Moon, at once, appears at the former Place, at X in the Morning; and at the later, at II Afternoon; and when she Culminates upon the Central XII, as lying Equidistant from 'em both, and being the Point from whence the Tide diffuseth itself, towards both Places with equal Speed; and consequently affects 'em at the same Time; the one, as XII at Noon; and the other as at II in the Evening, with regard to her present Position. Yet, in Consideration that High-water reaches neither Place, 'till she has pass'd the said Line fifteen Degrees to the Westward; that Half Space, which was added to the II at C. Finisheth to make Tide at III; must be subtracted from the XII at Manomy Point, to leave XI only according to Observation.

Now, to turn the Compass around upon the Central XII, according to the same Extension as soon as this spreading Secondary Tumour toucheth C. Finister at III; it doth the like to the Easterly Promontories of Europe; from the utmost North of Ireland, to the farthest South of the Canaries: So on the opposite Coast of America, the said XI, is derived from Manomy Point in New-England, to the mouth River, Boston Harbour, the R. Penobscot &c. towards the Norward, as far as the Compass of our Observation, and the Sphere of Activity, extends; while the Primary Flood supplies the Remainder of its Circle, beyond that Extent; from C. Bajador in Africa, to C. Florida; and thence along the American Shores, up to Gay-Head in New-England, the same Instant: So exact was the Account of the Primary Tides, amongst themselves

at how it comes to pass, that this *Secondary* sort, which consists of *one* single *Hour's* Diffusion, shou'd affect the Places aforesaid, *three* hours later than they ; will more fully appear, in the following *Section*.

S E C T. V.

Of the mutual Occurrence of the Primary, and Secondary Tides, at the Places aforesaid.

THE *three* Hours Precedence of the former Sort of Tides, being already evidenced, by many Instances produc'd for that purpose ; and concerning their mutual Occurrences, I here only insist upon those *four* Places, which are remarkable, for the joint Continuance of both their Circuits in one, viz. at *Bajador*, and the *Canaries*, on the *African* Coast ; and *Gay Head*, and *Manomy Point*, on the *American* Coast.

Concerning their former Conjunction, the *Indian Pilot*, tells us in general Terms ; that the *S. Moon* makes High-water at the said *Cape*, at *XII* ; and a *S. W. Moon*, at the more *Western* of those *Islands*, at *III* ; that is, *three* Hours later ; leaving us to calculate the several Intervals of Time, and Points of Place of their immediate Occurrences ; from her correspondently diverse Aspects, all the while.

Contrariwise, our *West-Indian Pilot*, to satisfy our Curiosity, even to the nicest Particulars of their said Occurrences, from *Gay Head* to *Manomy Point*, in both respects : Af-

and *Martha's Vineyard*; and is divided in
 Passage, into a *Western* and *Eastern* Cur-
 rent; the former, being deflected by *Mentock-*
Point, towards the *N. W.* Cape of *Block-Isle*;
 while the Backside thereof, deflects the other
 Branch of the Stream *Eastward*, towards *Gay-*
Head; where, upon an *equal* Repulse, the
 Flood is made to swell at both Places at once,
 wit, at $\text{VIII} \frac{1}{4}$; an Hour sooner than else-
 where, upon that Coast; but exactly when
 it makes at *C. Bajador*; tho' above a thousand
 leagues distant from it.

Next, The *Western* Current, deflects its
 course to the *S.* End of *Fisher's-Isle*, while the
Eastern passeth to *Tarpolin Cove*; and both
 swell at IX , (which is near the *regular* Hour)
 in accord with the *Central* Flood of the *At-*
lantic, at XII ; which, being also of the
 primary Sort, and rais'd by the same *Libration*,
 swells near the same Time; all Impediments
 being remov'd.

And, to pass from *Fisher's-Isle*, to the *Horse-*
Shoal, which runs between it and *Gull Isle*, where
 the Water ripples for fast, both at Flood and
 ebb, tho' the Channel be *twenty Fathom* deep;
 at the Tide (having the Gulph to fill as far
 as *New-York*) floods not, 'till the *Eastern* Cur-
 rent have crept over the Sands, to *C. Poge*;
 that is, at $\text{X} \frac{1}{2}$; an Hour and a half later, than
 it does at the *S.* End of the aforesaid *Isle*.

After all, this Stream reacheth *Manomy*
Point, at $\text{XI} \frac{1}{4}$, where it meets with the *Se-*
condary Tide; which arrives there from the
Central XII , at the same Instant; and three
 Hours later than it made at *Gay-Head*, viz. at
 $\text{III} \frac{1}{4}$; and at the same three Hours Distance,

that the *Secondary* Flood occur'd to the *Primary* XII, at C. *Bajador*, viz. at III Afternoon.

Hence plainly appears, 1st, That the *Primary* Tide, which devolves from the *Central* XII, requires only *one Hour's* Precedence, to spread the *Secondary* one over the *Atlantick*, to the utmost Extent of its Circuit: 2^{dly}, That it acquires but *one single Hour's Acceleration* extraordinary, by its Appulse to C. *Bajador*, and *Gay-Head*; where it obtains a *second Hour's* Precedence, before the said *Secondary* one: 3^{dly}, That the *third Hour* is advanc'd only respectively, to the different *Position* of the Moon; which, by her *Diurnal Tendency* to the *Westward*, *fifteen Degrees* beyond the *Central Meridian*, seems to *add* to the *Eastern-bound Tide*, an *Hour's Retardation*; to make it at III, instead of II Afternoon; as it doth at C. *Bajador*, in respect of the *Canaries*: And contrariwise, from the *Westward-setting Flood*, *subtracts* the same Space of Time, by her *Tendency* to the same Point; so as to make it flow at XI, at *Manomy-Point*, instead of XII; that, as the *Southing Primary* Flood, at C. *Bajador*, preceded the *Secondary* III at the *Canaries*, at *three Hour's* Distance; so may the *Primary* VIII $\frac{1}{2}$, at *Gay-Head*, correspond to the *Secondary* XI $\frac{1}{4}$, at *Manomy-Point*, to an Instance

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So exact is the Accord of the *Primary* Tides of this *Séa*, as to reach their *Summits* every where at once, by *Libration*; and their *Secondary* ones, which swell by *Undulation*, flow at

ual a Time, around their Circuits : And
Sorts, observe as percisely a *three Hour's*
ance from each other, between their
bern Tropick, and the *Artick Circle* ; as I
demonstrated : And, to evince, that they
as strict a Correspondence, both as to
, and *Place*, with those on the *other Side*
their common *Axe*, between the said *Tro-*
and the *Equator* ;

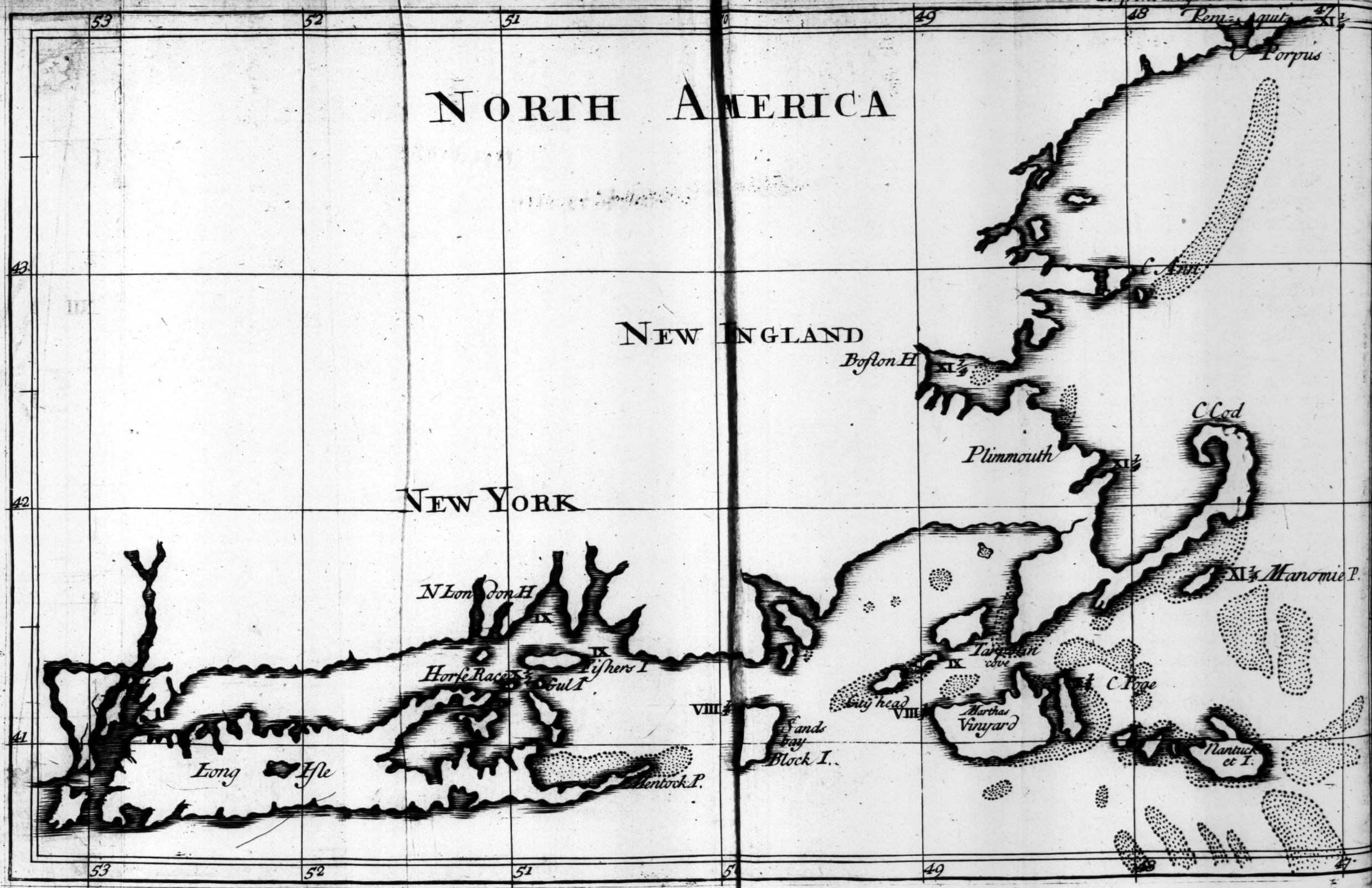
ft, concerning the *Primary Sort* : Where-
the Water flows upon the *Central Me-*
of this Tract of Sea, about *twenty-three*
degrees Latitude, on this Side of the *Tropick* ;
answer'd by VI, upon the *same Meridian*,
e it Intersects the *Equator* ; not far from
ajana, where the Tide makes at VI : And
e Mouth of the *R. Amazonas*, a Quarter
a Hour later ; which corresponds, by
er-Libration, to XII at *C. Bajador*, to VII $\frac{1}{4}$
rolina, and VIII $\frac{1}{2}$ at *Gay-Head*, &c. as a-
id, at the *same Time* ; tho' *diversly* deno-
ted by the Moon's *different Aspect* to
three Places, at one and the same indivi-
Instant.

xt, as to the *Secondary Tides*, which are
sted from the *Primary XII*, on the Cen-
f the *Atlantick*, towards the *Eastern* and
Shores ; the III^s, described on the
rn Promontories of *Europe*, and *Africk*,
is *North* side of the *Tropick* ; are answer'd
X^s, on the other in the *South* ; at *C. Blan-*
nd *Sierra Leone* : As the XI^s, along the
rn Coasts of *New-England*, are, by the
instead of V $\frac{1}{4}$, at *Surinam* (if it had lain
equal Distance from the said *Meridian*) :

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To answer the said XI^s, at *six Hour's End* ; As at the *former Place*, near an *Hour* before the *Moon's South'ing* ; so at the *later*, as before her *Setting* ; to make their *Return* hourly, from each *Side* of the *Tropick*, alternately ; whether they be of the *Primary* made by *Libration* ; or of the *Secondary*, which are deflected from 'em by *Undulation*, at *Hour's Distance* ; and happen so much later

Such is the *general Accord* of these *Tides* at all *Places*, and so mutual is their *Correspondence* of *either sort*, amongst themselves, each *Side* of their *common Axe* : And their *Actions* are still so proper, and fitly adapted to the *Places assign'd* ; and their *Performances* distinct, and pursuant to each other, they must necessarily depend upon some *universal Cause* : And still keeping as exact *Tune* with the *Course of the Moon*, in all *Cases* ; most resenting her *Presence*, by *stopping* lowest to it ; and the *Water* mounting in her *Absence*, by *Rebound* alternately ; *Pressure* must *first cause* them, and their *weight Advance*, and *propagate* 'em afterwards by *Libration*, and *Undulation* (as *afore-said*) in the wide *Ocean* : But, lest the *great Difficulty* of their *Performance*, in this most *irregular and unaccountable Sea*, shou'd seem particularly to *obscure* this great *Truth*, and *Doubts* to the contrary ; I shall endeavour to clear 'em all off, one by one, in the following *Section*.





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S E C T. VI.

ning Irregularities of the Atlantick Floods,
in'd, and clear'd.

RST, Whereas it may be objected, that the Atlantick Ocean, being of no regular Figure, cannot admit of a Center in the strict Sense, more than any Conick Section, is excepted: *Ans.* What I assign, is such a Point, or Place, as seems to be regarded by the Tide's Diffusion; as spread itself from thence with most Equality, to the surrounding Shores.

That no one Place seems assignable, where the Tide can possibly so affect the Shores, as to make at once, on the Western Frontiers of Ireland, France, Spain, and Italy, whose utmost Points lie almost in a Line, for near five hundred Leagues together. *Ans.* Yet, that Part of the Atlantick, which is affected, being partly Triangular; the Tropick, which is the Axe of the Tide affects it, being its Basis; a Tumour of the Figure, and such as the American Shores, on the one Side; and the European, African on the other, will admit; and is form'd, as in a Mould, by their Resistance; is sufficiently accomodated to continue the Work, at near the same Instant, on the Shores abovesaid.

To urge this Difficulty farther; it is not practicable for the said Tumour, to rise to the Bottom of the Bay of Biscay, even to the Mouth of the Garrone, as soon (within half

half an Hour) as it affects the extreme Parts of the said Promontories, which shoot themselves forward near *three hundred Leagues* further into the Ocean : *Ans.* And it were solutely impossible, for it to be hurried with so great *Celerity*, from the Top to the Bottom of that Bay ; did not the Sea, within the Promontories, run the *highest* ; and consequently the *deepest*, to make way for it, of other on the Coasts of *Europe*, or elsewhere (that one, near the C. of *Good Hope*, excepted). And, on the contrary, were not the Promontories fronted afar off, and guarded with shallower Water, and *shelvy Bottoms*, from hasty Approaches, and Insults of those Tumours, they must necessarily be flooded sooner, than they be at present.

4^{thly}, Yet be the Conveyance of the Water, as speedy as it will, the Central Flood of the *Atlantick*, cannot be diffused to the *Streight of Gibraltar*, by Anticipation ; as the Moon *Souths* upon it ; which happens an Hour and a half before the Sea be full, on the Great Meridian : *Ans.* To this I reply'd ; that the Moon brings along with her thither another Flood, by her immediate Influence upon the *Mediterranean Sea* ; which concurs with the Central Half-Tide of the *Atlantick*, jointly swelleth the *Streight's* Water higher, than can be possibly done, after the *Mediterranean* Tide's return towards the East ; whence it came.

5^{thly}, When it is urg'd ; That at C. *Baj* on the Coast of *Africk*, between the *Streight* and the *Tropick*, the Water also flows at XII, tho' it has no Communication

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Midland Flood, to hasten it ; nor can it
 proceed so speedily from the *Central Tide* of
Atlantick, at so great a Distance from it :
Ans. Nor is it requisite to flow from *either* of
 ; or partake with 'em ; more, than to be
 supply'd, immediately with Water, from
 within the *Tropicks* ; and by the same Tidal
 pulsation, which replenisheth the rest of the
Atlantick, and at the same Time ; having its
 proper Channel, between the *Canary Islands* and
African Shore, to convey its proportionate
 part of the Stream all along, from the *Equa-*
tor thither ; as soon, as to any other Part of
 the Sea ; and by Inclination of the *Shores* on
 both Sides, to raise the Tide there *an Hour*
earlier, than at the Center of the *Atlantick* itself.
6thly, If it be still insisted on ; that, to the
 contrary, about *Cape Cantin*, near the Middle
 of the said Shore, between the said *Streight*
 and *Cape Bajador*, (upon both which *XII* is
 fix'd) it flows not 'till *I* ; *Ans.* It is not
 to be wonder'd at, that the Flood shou'd come
 much later, to the *Middle* of that Coasting
 current, than to both the *Ends* thereof, upon
 whose Floods it jointly depends ; as being the
 proper Cause, whereby it is produced ; and
 consequently it must swell later, and not with-
 draw itself again, 'till after their Departure.
7thly, If the Tide seems to be either too
 quick, to make at *Cape Bajador* at *XII* ; or too
 slow, not to reach *I. Canary* 'till *III*, after-
 wards : *Ans.* At the former Place, it is fur-
 nish'd with Water immediately from the *Equa-*
 tor ; and is withall, accelerated by inclining
 shores : Whereas, at the later, it expects the
 refluxion of a *Secondary Flood*, three Hours
 longer

longer, from the Center of the *Atlantick*, which it lies exposed.

8thly, If it be objected ; that, at *C. Blanc* it makes *six Hours* later, than at the said *Ile* to wit, at *VI* ; tho' both lie in the *same Degree* of Longitude ; and in Latitude not above *Degrees* distant from each other : *Ans*w : It is because they lie on *different Sides* of their *Ax* and so are *counterposed* to each other, at *Hours Distance*, tho' they lie so near together.

9thly, Yet it does not appear, why *Sier Leone* has two *distinct Tides*, the one at *VII* and the other at *IX* : *Ans*w. It is, because they are derived regularly, from two as *different* situated Oceans : The former from the *Ethiopic*, and the later from the *Atlantick* and they correspond each to their respective Tides ; the *VII*, being consequent to that of *R. Serbera*, which swells an Hour before it and the *IX* to the *III*^s, on the *Western Promontories of Europe*, &c.

10thly, At *R. Gojaven*, 'tis Tide *two Hours* sooner, than at any other Sea-port, on all the same Coast : *Ans*w. 'Tis, in regard *Cape Palmas* over-shooting the rest, drives the Current of the Sea into the Mouth of the River, with so much Precipitation, as to hasten and raise the Tide, at their joint Appulse to the Shore to a greater Height, than to be kept up any longer to the same Pitch.

11thly, The Water floods twice, at *I. Capna*, at two Hours Distance : *Ans*w. That is to say, once, being over-hastily swell'd, like the first at *Gojaven*, by the joint Appulse of the Flood and Current, to the Shore so much too soon and the second Time, not before the regular Hour.

Lastly, The Flood at R. Gabon at VI, anti-
 gates those on our *Western Promontories*, which
 will not 'till the third Hour, after the Moon's
 passing upon 'em; and shou'd happen at
 three, to correspond with the III^s at the C. of
 d Hope, beyond the *South Tropick*, at six
 ours Distance: *Ans^w*. The Parity holds not,
 a double Account; this Flood at VI, be-
 Primary; the Stream which supplies it,
 aves to the *North* and *South* Shore, which
 out into the Ocean to meet it: Not a Se-
 ary one; to expect the Moon's passing for-
 rds two Hours, and the Flood's Return
 k to the Shore in the third Hour, before it
 possibly happen.

After all, if it be *question'd*, why R. Gojaven,
 an, Rey, and Monamba's Hole, each swell
 in one Hour's Space, above the rest of
 the Rivers on the same Coast. *Ans^w*. 'Tis
 cause the *Mouths* of the said Rivers, are re-
 markably *reflected* towards the flowing Water;
 ch, being obliquely driven by a *strong Sea-*
rent, swells highest at its Appulse to the
 ositely reflected Shore, two Thirds of an
 ur, before its Flux ceaseth: And sinking a
 le, after the Briskness of the Flux is over,
 ounts again with the flowing Water, to
 atmost Pitch; the Top of the Tumour be-
 , as it were, divided into *two Half-tides*,
 ore it pass into an Ebb.

But, to cast an Eye of Reflection upon the
 ern Shores; the Appearance of Irregulari-
 eems, at the first Sight, to exceed ail our
 'd Observation; *viz.* That an E. S. E.
 on shou'd make at *Florida*, at VII¹/₂; along
Virginean Coast, a S. E. at IX; and a S. E.
 E. at VIII¹/₄ at *New-England*: But, upon a
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second Inspection, subtract *one Hour's Acc*
ration from *C. Florida* (*Virginia* being regul
 and *another* from the Account of *New-Engla*
 and at the *First Place*, it makes at *VIII*;
 the *Second*, at *IX*; and at the *Third*, at *IX*
 Which agrees exactly with the Moon's *diffe*
 Positions to the *Declivity* of those Shores:
 as to adjust the Tides, at all those *Three Pla*
 to the *same Time*.

CONCLUSION.

Having examin'd the various Appearance
 the Tide, in our *Western Ocean*; and clear'd
 seeming *Irregularities* of the *Atlantick* Part,
 special Manner; which, for Multitude and
 versity, must exceed *all* that are incident to
 other Divisions of that Wilderness of *W*
 which encompasseth the *Universe*; as much
 the *Anomaly* of its Figure, and the *Unacco*
bleness of its Situation surpasseth theirs:
 this, with regard to the sole *Efficiency* of
 Sun, and Moon, by Means of their comm
 Instrument, *Pressure*; proceeding constan
 from the *Cause* to the *Effect*:

Now, upon my Departure from the *v*
Ocean, to our narrow *British Seas*, I am, *e*
verso, to argue from the *Effect* to the *C*
 that is, from the inextricable Maze of *C*
nels, and *Currents*, and the *confused Scene* of
 dal Occurrences, which it exhibits, not to
 parallel'd: That, upon a clear and man
 Display, they are all *reconcil'd* amongst the
 selves, with that Perspicuity, as to exclude
 reasonable Doubt to the contrary; and
 they are all conformable to the same *Order*
 Nature, and Laws of Motion.

C H

C H A P. IV.

of the Tide's Reception into our Irish and British Seas.

TO give the Motion of the *Tide* a successive Designation, in both the propos'd respects; First, as to the *Place* whence it is to be drawn, it is the Center of the *Atlantick Ocean*; where it is rais'd by *Libration*, and wells alike by *Result*, from the New and Full-Moon's Pressure; but is not full Sea there, till they have attain'd to their Meridional Height between the *Tropicks*; and so cannot reach *Ireland* by *Undulation*, 'till after their Southing: Hence the Primary Full-Moon, or Secondary New-Moon Tide, which makes *Midnight*, and usually visits the *West* of *Ireland*, at III, and the *West* of *England*, at IV the Morning; and is call'd the *Day-Tide*; which is most opportunely to be made Use of, as remaining under our constant Inspection, from Morning 'till Night.

This Secondary New, or Primary Full-Moon Tide, no sooner visits the *West* of *Ireland*, but divides itself by *Fluctuation*, or a divided Flux of Stream, into N. and S. Floods; and each Stream sub-divides into Two more: the two innermost, including the Principality of *Ireland* only, re-unite themselves at the *Order of Man*; while the other Two outward-bound

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bound

bound Ones do the like at *Hull*, after they have encompass'd *Great-Britain* also: Hence, its Motion appears to be every where progressive, as to its *Main Course*; and most *Regular*, where it is remotest from Coasts and Shores, either to deflect its Current, or retard its Speed; Yet, as to the *Manner* of its Progress, it becomes almost every where very *different*, in some other respect: So that every *Branch* thereof is to be traced along its respective Stream, apart; and first down the Middle of the *Channel*, where it is least Obnoxious to such Impediments.

S E C T. I.

The Tide's Division, by sundry Channels; its Progressive Motion, thro' as different Roads; with Regard to the TIME and PLACE of High Water.

TO begin with the *English Channel*, which lies nearest to our Inspection, and best deserves it, both for the Multiplicity and Variety of its Appearances; and trace its Course from the Promontories of *Ireland* (where it makes, on the *Western Coasts*, at III; and on the *Southern*, at IV in the Morning), and follow it thence (as the *Arrows* in the Map direct), towards the most *S. Western Point* of *England*: It swells, over against *Falmouth*, near the *Lizard*, about V; and passeth by *Plymouth*, the next Port to it, at VI; and down the Middle of our Channel, before

Dart

Dartmouth, at VII ; *Portland*, and *Weymouth*, at III ; by the *Isle of Wight*, at IX ; 'till it reach *Dover*, at X and $\frac{1}{2}$: And having pass'd the *Strait of Dover*, and left *Calais* after XI, it comes to *Dunkirk*, on the *Netherland-side*, about XII ; passeth by *Goree*, at I and $\frac{1}{2}$; and before the *Isles of Rhé*, at II $\frac{1}{4}$; and reacheth the Clifts of the *Texel*, at III and $\frac{1}{4}$; still following the Direction of the same Shore, all along the *North Sea*, or *German Ocean*.

But deflecting thence towards the *South Sea*, which lieth before *Amsterdam*, thro' the Streights of *Texel*, at VI ; and of the *Fly*, at VII ; and following their several Channels, along the Coast of *Friezland*, 'till VIII ; they conjoyn in one, at IX ; which passeth by *Horn*, at XII ; comes to *Amsterdam*, at III ; and arrives after at *Harlem*, where it finisheth its Course, at I : So regularly Progressive is the Tidal-Flood down the Middle of our *English Channel*, and along the Coasts of *Flanders* and *Holland* ; and punctually are its Stations set down, on each side ; where Ports, as it were *Land-marks*, shew out what Way its Tumour makes, even an Hourly Performance ; on Our Side, from the West of *Ireland*, as far as *Dover* ; and on theirs, from *Calais* to *Amsterdam*.

And, to return to the Western Coasts of *England*, whence the *Northward-bound Division* of the aforesaid New and Full-Moon Flood departed, at the same III Hours ; it moved to the West Side of the *Orcades*, at IX the Morning : But being to encompass all the *Shetland Islands*, at two Degrees farther North ; and withal to swell the whole Extent of the Sea, between the Coasts of *Norway* and

The Motion of the Tide,

those *Islands*, before the Flood cou'd be reflected thence, and reach the same Height on the East Side of the *Orcades*, it arriv'd Thither 'till III in the Afternoon: Nor did it affect the Road before the *Fair Isle* (which lies betwixt 'em) 'till about XI; (which is their *Mean Time*,) as is found by Experience.

But to continue the said Flux of the Tide from *Fair Isle* Road, where it swells after it comes down the *German Sea* to the *Dogger*, where it meets with the *South Flood*, and incorporates with it; It is to be observ'd, that it exceeds not XI and $\frac{1}{2}$, along the Coast of *Norway*, 'till it have pass'd the *Naze*; and so continues to make at XII, or thereabouts, along *Denmark* and the *Futland Islands*, 'till it reach the East-end of the said Bank: And as the Tide makes not, on the *Shore* of *Fair Isle*, 'till about III in the Afternoon; that is, four Hours later than it does in the Road: So upon the Coasts of *Scotland* and *England*, it continues to make so much later, than on the opposite Shores of *Norway* and *Denmark*; that is, either at, or after III, on the *Forelands* of both Nations; 'till it reach *Flamborough-Head* about IV, over against the Road aforesaid.

Now it is remarkable, that, altho' the Flood passeth along *Norway* and *Denmark* along a straighter Coast; and withal according to its first Direction, from within *Fair Isle* Road. And, on the contrary, is considerably reflected from it, towards the *Scotch* and *English* Shores; yet its Course to *Doggerbank* is not patcht, on both Sides, at the same Rate; but, wit, on the Former, between XI and XII

and on the Later, between III and IV ; that
s, within the Space of *One Hour*, on either
side alike : Hence it must be concluded, to
to the same down the *Middle Stream* (where
it meets with no Impediment) ; and to make
upon the *Middle* of the said *Bank*, at XII ;
and perhaps somewhat sooner at the *East End*
of it, and later at the *West End* ; or rather,
in regard that the *South Tide* meets it briskly
towards the *West*, and decays afterwards ; 'tis
full, all along from the one End to the other,
at the same Time.

Having thus disclos'd the *Place* of the Con-
fess, of the N. and S. Floods, to be the said
lands ; and the Time to be at XII, by the
length of their Courses thither, in both re-
pects : It is farther manifest, that they joynt-
ly rais'd the said *Bank* as a Barrier, to break
their mutual Insults upon each other ; and
that the *Elbe, Rhine, Maes, &c.* brought down
their Wreck from *Germany, Switzerland, France,*
&c. which composeth it ; being not a Work
of the *Creation*, but a Heap of *Mudd*, washt,
by the beating of their Waves, into a *sandy*
bank ; planed on all Sides, into a rectilinear
long Figure, by the *Streams* which laid it
there, to cover the Coast whence it came ;
and that it became *separated* from the Land,
by the Interposition of the *South Flood*, which
truck in betwixt it and the *Netherlands* ; and
nally, was parted at each End, from the *English*
and *German Shores*, by Channels made by the
the *North Tide* ; which sloap'd off its nether
corners, to leave a free Communication be-
twixt their Streams : As the greatest *Rivers*,
when they cast up Banks of Sand, to secure

their Ports, commonly keep *more* Channel open than one, to disembugue their Flood with more Freedom into the Ocean.

So constant and regular is the progressive Flux of the Tide, down the *Middle Stream* of its Channel, around our Coasts: Let us see what *Rubs* it meets withal near the *Shores*, to hinder its Passage, or deflect its Course into so great a Diversity of Motion, as to be otherwise unaccountable.

S E C T. II.

Observations and Reflections upon the Division, and Progression of the Tide, described in the precedent Section, with regard to the Shores.

TO begin my Reflections on the *West of Ireland*, where I first enter'd upon the said Description; it is observable, that the Tidal Flood found a *free and open* Passage before the *South Coast* of that Kingdom, 'till it enter'd the Chops of our *English Channel*, between *Ushant* and *Silly*; and held on its Course to the *Eastward*, down its *Middle Stream*, at almost the same Rate, of Time and Place progressively, from the *Lizard* to *Dover*, the Coast being favourable, and its *Foreland* lying almost in a direct Line; and the *Bays* betwixt 'em being so little depress'd, as to give it no considerable Stop, or Deflection for at least a *hundred Leagues* together.

Whereas, on the contrary, it is no less remarkable, that athwart the *South of England*

beyond the Channel, on the *French Side*; that Tract of Sea, which corresponds to ours, is divided into *Two Bays*, or *Gulphs*, of a large Extent; the One, reaching from *Ushant*, to *Cape Hague*; and the Other from *Cape Barleur*, to *Calais*; which break the Course of the Flood, on that Side, as it were into *Starts*, from one Head of Land to another: And certain several *Rocks*, and *Islands*, which often stop, and sometimes force the Flood to recoil whence it came; after they have rais'd its Tumour to its full Height, two or three Hours sooner than ordinary.

The first *Rub*, that this Eastward Progression of the Tide meets with, is the *Western Shore* of *Ushant*; upon which, its Flux from the Ocean, falling, as it were, from a higher Sea into lower Water, raiseth, by Rebound, a greater Tumour, than to be supported by the Flood which brought it, any longer than the Dint of its first Impulse lasteth; and by this means, makes at III and $\frac{1}{4}$ in the Morning, *two Hours* sooner than in the *Channel* it self; which has the *Gulph* below it to fill, before it can arrive to its full Pitch, at VI: And the like happens at *Garnsey*, some Leagues down the Current; where, to the Sea-ward, it makes at V and $\frac{1}{4}$; yet, in passing down the Channel, not 'till IX and $\frac{1}{4}$, full *three Hours* later: And it must do the like, at all other Places, which confront the Flood, to set it on; and are flank'd by Channels, to carry it off again.

After the Tide has pass'd the *Ushant*, the next *Rub* that falls in its Way is the *Normand Promontory*; which dams the Stream on that Side,

Side, transversly, from *Cape Hague* to *St. Malo's*, which lies in the Bottom of the Bay; where 'tis Flood at V and $\frac{1}{4}$, and the Highest perhaps in *Europe*: so that it both precedes and exceeds That in the Channel at *Ushant*, whence it Flows; tho' at *twenty Leagues* distance from it; which seems ('till both be well consider'd) to make the Effect to anticipate, and surpass the Cause that produc'd it: And the like must happen, proportionably, upon all that Coast, from the *Cape* to the *Port* aforesaid, and consequently co-extend to the *Gulph*, along the *French Shore*, from *Ushant* thither.

But the Flood having pass'd thorow the Streight, between the said *Cape* and the *Start* down its common Road; while it slips by *Portland* at VIII, the *Isle of Wight* at IX, and reacheth *Dover* at X and $\frac{1}{2}$, it spends all that Time in doubling the *Cape Barfleur*, before it arrives at the Road of *Caen*, where it makes at X and $\frac{1}{2}$: And continues to do the like at the same Hour, all along the Coast of *Normandy* and *Picardy*, from before *Caen* down to *Calais*: The Lines of the Tide's Diffusion from its direct Course, to those Transverse inclining Coasts, growing still proportionably shorter, and consequently supplying 'em with Water so much quicker; 'till their Distance both in Time and Place, be concenter'd in Point, at the Streight between *Dover* and *Calais*; so as to render the Making of the Tide along those Coasts, with regard to its Eastern Course, instantaneous.

And from the Streight at *Dover*, the Sea is full before the *Downs* and *Harwich*, as far as the *Yarmouth Road*, at the same Hour that it Floods

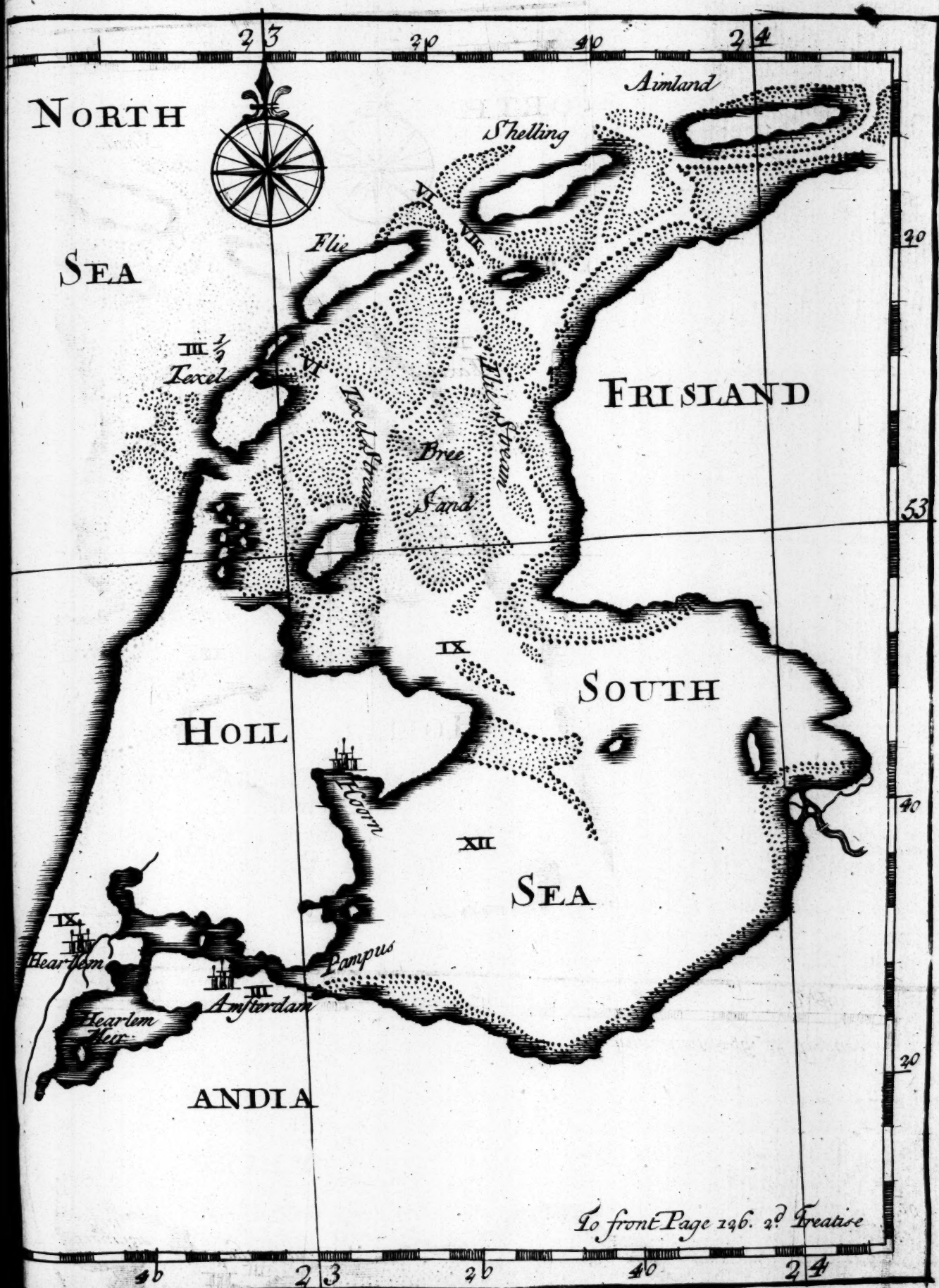
the Coast of *Normandy* and *Picardy*, for a-
 ve *sixty Leagues* together ; tho' it be *diversly*
 caſion'd : Because, along thoſe Provinces of
 ſe, the Shore ſo *inclin'd* towards the *Mid-*
Stream (which ſwell'd ſucceſſively) that
 farther they went, it was proportionably
 quicker ſupply'd : But here, upon the
 ſalts of *Esſex*, *Suſſex*, &c. the Flux of the
 ſes, being partly reſiſted by the *Sands* be-
 e *Yarmouth* ; and partly repulſ'd by the Oc-
 ſe of the Northern Flood, ſwells equally
 both Ends, and thro' all the intermediate
 ſt of Sea, at once ; as alſo upon the ſame
 ſt Line, as long as the Water riſeth at
 ver to ſupply it ; that is, for *five* or *ſix*
 ſ Space ; to make High water all along,
 m *Caen* in *Normandy* to *Yarmouth* in *Norfolk*,
 he ſame Inſtant.

and when the North and South Tides meet
 wards upon the ſaid *Sands*, at XII, and be-
 e united into One ; it is after ſuch Man-
 Nor, that altho' their joint Flood co-extends
 the whole Coast of *Flanders* and *Holland*, at
 ſame Hour, on the *Road*, ſo as to fill All
 e in, at once ; yet it creeps progreſſively up-
 nably the *Shores*, for *five Hours* together ; that is,
 a with in *Calais* about X in the Morning, to *Texel*
 ſtance at III in the Afternoon ; as I have already
 d in ſcribed ; each Flood, notwithstanding their
 d Ca conjunction, perſiſting to produce its ſpecial
 Tide ſet : For, in regard the *German Sea*, opens
 Eaſtward wide enough towards the *Northern*
 n, to receive its Tidal Impreſſion in full
 Sea i ſaſure ; and is deep enough, to convey it
 far a rely to the *Digger-bank* ; and continues to
 Flood ſame Breadth, to comprehend it all at
 on once ;

once; 'tis proportionate, in every respect to effect it *All* at the same Time, especially being *directly* objected against it: And it is no less proper for the *South Flood*, inasmuch as it is sharpen'd by the Streightness of its Passage, at *Dover*; and withal, directed towards the *Netherlands*: To continue its Flux at a competent Rate, along their *Shores*, in compliance with the Impulse and Direction aforesaid.

After all, this Coasting Tide sets, from *N. West*, upon the Cliffs of the *Texel*, at *Afternoon*; and at *IV*, at the *Fly*; it makes not *before* them 'till *VI* and *VII* Night; being deflected from its *Eastward* Course, into the *South Sea*: And withal, being almost spent by passing over the *Sandbanks*, makes so little Way down their crooked and narrow Channels, on the Coast of *Frisland* and before *Horn*; that a second Flood succeeds this at *Texel* before it can reach *Amsterdam*, and *six Hours* e'er it advanceth to *Harlem*, to finish its Course; as 'tis delineated in the following Map of *Holland*.

Such is the Speed and Regularity of the Flood, in *direct* and *open Channels*, as I described in the last Section; and, on the contrary, it becomes so disorder'd, and retarded by the *flecting Shores* of *shallow Water*, as I demonstrate in this; the Tide flowing all the while. But *Why*, upon its Ebb, it shou'd make High Water in some Places, where it was Low before, still remains to be discuss'd.



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S E C T. III.

Now the Flux of One Tide produceth Another by its Reflux ; and that One Flood may become Many, by a diverse Application to the same Shore.

THUS far I have traced the Course of the Tide, as proceeding from the Ocean progressively, either by a direct, or deflected path ; and display'd its sundry Appearances, on such accounts : But being found by Observation, that its Reflux sometimes raiseth Tunnours, where the Flux had produced none before ; and all this while, no greater quantity of Water was return'd by the same Channel on occasion it ; especially it happening near the time of Low-water, and after so odd a manner ; that whereas in some places, the rising Flood only wash'd the Shores, the retreating Ebb spared them, and swell'd the Channel ; and in others, the Flood made High-water to the Sea-ward-side of the Islands, and the Ebbing-water to the Lee ward afterwards : 'tis Remarkable, that, in those Cases, the Inclining Shores render'd the Tide, at its return, so much more compact and forcible, by contracting its Stream closer together, as to perform the said Effects.

For an Instance of the former Sort, it is serv'd to be High-water at Dover about X $\frac{1}{2}$; and at Calais at XI in the Morning ; in the Streight, or Channel between them, to swell to the same Height, until III in the afternoon upon its Stream's return from the

the Coast of *Flanders*: For, whereas the Current, passing thro' the Streight aforesaid, between X and XI, had free liberty, upon the Confinement, to mount *both Shores* at once yet cou'd not rise to its full Height in the *Channel*, being carried off too speedily, three several Ways at once; viz. towards the *Dow* *Flanders*, and *France*: But now at III, upon triple Confluence of all their Streams, in the Mouth of the said Streight, it becomes swell'd up in the Middle, by 'em *All* at once; and its Tumour is so buoy'd up from each Side by the Occurrence of the two adverse Streams from the *English* and *French* Side, as not to it affect the Adjacent Shores.

Of the *later* Sort is the Tide at *Ushant* where it makes, by its Flux from the *Man* into the *Bay* towards the *West* at IV and the Morning; and yet is not full Sea, on its *East* Side, by its Reflux out of the *Channel* till XII at Noon; the Stream, on its return along the *Inclining Shore* of *Little-Britain*, being more contracted, and hasten'd Thither, rather than towards the opposite Side of the *Island* where it flow'd before.

The like happens at *Garnsey*, which is situated in the Sea, upon *Cape Hague*, the Foreland of all *Normandy*; which, straightning the *South Channel* to the *Half*; makes the Ebb, at its return from the *East*, fill that Side of the *Island* full at XII and that was empty before; when it Flow'd at VII, on the *contrary* Part: And the same Judgment is to be made of all other *Islands*, which lye Open to receive the Flux of the Tide on the one Side; and withal near some

ing Shore, to contract its Reflux more Intensely, on the Other.

And upon all the abovesaid Accounts, the Flood affects the *Isle of Wight*, on all Sides respectively, at different Hours : First, on the West Side, as being directly oppos'd to the flowing Stream, the growth of its Tumour is consequently hasten'd by it, so soon as to III in the Morning : Next, on the South Side, which lyes towards the Channel, the Tide is carried off again by it, at IX : Then, on the N. West, where the Tide and the Race meet on the backside of the Isle, before *Calshot*, the Water is full at XI : After that on the N. East, the Flood has at *Portsmouth* a Harbour to fill, which detains it till past XII : And finally, it expects the Reflux of the Stream out of that Port, to meet the Ebbing Water from *Winchelsea* and *Dover*, at full East ; to well on their Occourse there, higher than before, about I and $\frac{1}{2}$; having spent full five hours space, in surrounding so small a spot of Ground ; which is near half as much time, as sufficeth to do the like to all *England* and *Scotland*, conjoin'd.

The like diversity of Tides, is also found to affect *Capes*, *Promontories*, &c. upon their different Applications ; as the *Start*, *Flamborough-head*, the *Lizard*, &c. that are washt by flowing Streams, which hasten their Tides on that Side, towards the Ocean ; till they let off again down the Channel, and are reflected afterwards to the *Leeward* successive, both to prolong their Continuance, and repeat their Tumours, by a diverse Access to the same Place : As without *Calais*, to be full

full Sea at I and $\frac{1}{2}$; towards *Dover*, at III; in the *Creek*, at IV and $\frac{1}{2}$; without the *Road*, at X and $\frac{1}{2}$; and at the *Peer*, at XII: Nay, sometimes it is *Progressive* on one Side of a *Cape*, and seems *Retrograde* on the other; as when it makes at X before *Dover*, it advanceth two hours forward towards *Quinborough*; and seeming to retire as many backward to *South-Hampton* to make full Sea at XII, with the Southern Moon at both Places.

But in case those *Promontories* &c. shoot directly into the Main, as on the *West Coast* of *Ireland*, where no such Currents thwart 'em, the Tide affects 'em an hour sooner, than the *Bays* within the *Capes*; and *These*, an hour before the *Ports*; whereas it fills the *Rivers* successively slower, the farther they strike up into the Land; as it doth all along the *South Coast* thereof; from *C. Clear* to *Waterford*: Hence it is High-water in the *Road* at *Harwich*, an Hour before the *Port* be full; and two Hours sooner before *Tinmouth*, than it makes at *Newcastle*; and three Hours at *Margate*, 'ere it is full Sea at *London Bridge*: And, whereas it flows on the *Downs*, at XII; at *Gravesend*, at I and $\frac{1}{2}$; and not at *London* till III; the Fifth Stage being twenty Leagues, and the Last but ten; and consequently the Course of its Flow grows doubly slower; Hence we may conclude, that it does so successively to the End of its Journey.

Finally, as to the Approach of the Tide on other *Coasts*, which are *Bold*, and hold to the same direction; 'tis both speedy, and all along Consequent to it self, to a Moment; but, the Shore prove either rough, or shallow; or

broke

ken by *Rocks* and *Shelves*, its Access becomes proportionably retarded; yet grows considerably slower, unless upon some remarkable *declivity* from the Channel, which supplies it; which is visible to the Eye, and is remarkable to the *Map* of the Place, without any further Elucidation: So that having display'd the *Course of the Tide*, as rais'd by the Moon's influence, between the *Tropicks*; and diffused over the *Atlantick Ocean*, by the counterpoise of its own Weight, in the Two precedent Chapters; and in *This*, having pickt up the chief Objections, objected against its Progress thro' our *Narrow Seas*, and remov'd 'em out of its way, to designation of *Place*, and computation of *Time*: It occurs to shew, how it becomes vary'd in *Height*, as well as *Speed*, both in our *Narrow Seas* which it affects; and in the *Ocean* itself, which produceth it.

S E C T. IV.

Brief Rehearsal of the most remarkable Occurrences of our British Tides, already discours'd

Since the manifold Divisions of the Tide in our *Narrow Seas*, and the great diversity of its Channels, have so deflected its Streams every way at once; that no known tract of Water, of the same Extent, ever branch'd it into such *variety* of Occurrences; that it seems to abridge all those, that are any where found in the *Ocean*, within so small a compass:

compass: I shall only recount a few, out so great a Number; which are most Remarkable, and explanatory of those, which I have contingently taken notice of, but not fully Explicated, elsewhere; referring the rest to the Inspection of the Map thereof, where is drawn a Scheme, which represents 'em at one view; and exhibits to the Eye the Connection and consequence more effectually, than Words can express.

First, One and the same Tide may affect several Ports at once, tho' they lye all on the same Side of the Channel, that successively supply's 'em; as along the Coasts of Normandy and Picardy, from Caen to Calais; or Ports be situated on the Opposite Coasts; as the Downs, Harwich, and Yarmouth; upon which, it Flows all along at the same Tide, tho' the Stream which supply's 'em, pass by 'em successively, one after another, not at the same distance.

Secondly, the same Tide may, contemporarily fill far remote Ports, by distinct Channels, they either lye at the like distance from the same Places, where their Streams were separated, as the Isle of Wight, does from Dublin; Rye, from Liverpool; which are alike distant from the Lizard, where their Floods were separated: Or, the same Flood may be convey'd by two opposite Channels, reflex to the same Place, so as to make sometimes one single Tide, when they meet there, else two distinct ones, when they are driven by the Wind successively thither; as at the Isle of Man; when the same Flood passes from the Ocean, by the North and South

Ireland

Ireland, diversly thither; while the same Tide passeth, in like manner, by the N. of Scotland and S. of England, to Hull; and makes but one Flood there, at the remotest Distance from the Ocean.

Moreover, in regard the Course of the Stream, while it flows in a *direct Line*, is perform'd with most Ease, and *greatest Celerity*; and every Deflection becomes a retarding *Impediment*: Hence, it is High-water an Hour sooner at Bristol, than at Bridgwater, tho' it be much farther distant from the Ocean, because it lies in a *directer Line* from it: And the Flood wells two Hours sooner at Dover, than at Portsmouth, which it passeth by, because it *deviates* out of its Road; and when it is arriv'd thither, it finds a *large Creek* to be fill'd with Water, which doubles the Impediment.

Besides, the Flux and Reflux of the same Tide, being jointly perform'd in *twelve Hours* space, in all Places, how circumstanc'd soever, according to the Stamp first set upon it by the Moon's Pressure, between the *Tropicks*; yet not so, as to be perform'd in *six Hours* apiece; but, by how much the longer the Flux is, the Reflux must be so much *shorter*, and on the Converse; according to the Capacity of the *Channels* which convey 'em, and the Situation of the *Ports* which receive 'em: Hence, *Rivers*, tho' supply'd by the same Flood, and close together, ebb and Flow at *different Rates*, and seldom at the same Time; as *Marshey*, and *Ribble*: The former spends more Time in Flooding than Ebbing, and the Former does the contrary; as wanting that *Fall of Stream*, which the other River has, to discharge itself, as soon as the Flux is over.

S

And

The Motion of the Tide,

And if the Places, affected by the Tide, lie in the *same* Tract, so as to be affected by it *successively*, one after another; the difference of their Tides, is to be calculated from their distance of *Time*, not of *Place*: Hence it is High-water at *Calais*, when it is Low-water at *London-Bridge*, and on the *Converse*; because it constantly spends about *six Hours* in passing between 'em; and not because they lie at such a *distance of Place* from each other, since it alike affects *Amsterdam*, and *Harlem*, tho' these be not *ten Miles* distant, and tho' they are near *thirty Leagues*: And in case their Distance either exceeds, or reacheth *twelve Hours* as the Tides do at *Plimouth* and *Hull*, or *Texel* and *Amsterdam*; they cannot be flooded both at *once*, by the same Tidal Undulation.

Nor is it so strange, that our *English Channel*, the *River Humber*, and *Zuider Zee*, shou'd *once* make High-water, by *three different* Tides at so great a distance of *Place*; as that the *Garrone* in *Gascony*, shou'd contain *Two* distinct Tides, and the said *Zee* as many at once for *six hours* space in *twenty four*; every Tide spending *eighteen hours* in passing that *River* (as well as thro' that *Lake*) *twelve hours* distance, the one from the other making High-water in the *Mouth of the River* and at *Bordeaux* at the same Instant, *different* Tides, the one succeeding the other at the said distance; and the leading Flood spending *six hours* more, before its Course is finisht at *St. Macar's*; yet fail not to make their respective Returns in due time.

Tide, Thus the Motion of the Tide, which was first
 d by impress'd upon that vast Wilderness of water,
 erence the Ocean in general; tho' throughout Homoge-
 n their neous, both for time and place; rising and falling
 e it perpendiculary, upon the Equator, and alter-
 -water nately, in six hours apiece; when it was boun-
 ; be ded with Coasts and Shores, the Tides became
 ours i diversly deflected, by their different Situations,
 e the from their former Regularity in both respects;
 other s appears by the more special Account, gi-
 darlem ven of 'em within the Atlantick: And upon its
 l tho Reception into our Narrow-Seas, new differen-
 eir D ces in those respects arose at every turn, into
 e Hour ach a diversity of Motions, and manifold
 l, or Occurrences, as I have already describ'd.
 flood Now, in regard it sprung at first, from a
 Undul ew Feet and Inches, near the Equator; to al-
 most as many Fathoms in other Places; I am
 Cham to shew, in the sequele of the ensuing Section,
 nou'd hat Advantage it makes of every step it takes,
 nt Ti om the one Extreme to the other.

S E C T. V.

f the Tide's diversity in HEIGHT; and how
 it is gradually encreased, both in the Atlantick
 Ocean which propagates it, and in our Narrow
 Seas, which receive it.

TO take the Dimensions of the Tide, aright;
 and draw the Encrease of its Height and
 ed, from proportionate Depths of Sea, and
 elinations of Coasts and Shores, along its Course
 m the Equator, whence it has its Origin, to

our Ports, where it terminates : I here reassume that *New-Moon Tide*, which I describ'd in the last Section, for a Pattern to follow thro' the *Atlantick Ocean* into our *Narrow-Seas* and remark what advance it makes at every step, in either respect.

The First Step, which the *New-Moon-Tide* monthly advanceth above the Ocean's natural Level, at the *Equator* (as we are told, from the Relation of a curious Observer) exceeds not *six Foot* ; whereto the *Equinoctial Flood*, superadds not above *six Inches* : whereas at *Brest* here in *England*, and at *St. Malo's* in *France* it reacheth *sixty* and *seventy Foot*, as is found by Experience : So that the Effect seems to exceed the Cause, from whence it springs, in a *Decuple* proportion : Now, to trace the said Steps in order, from the first to the last ; and shew, from the Connexion and Consequence of the whole Series, that they arrive only at an *Equivalence* each to other, all Circumstances being duly consider'd ;

First, It is observ'd, that the said *six Foot* Water, which, near the *Line*, is spread over all that Space of the Ocean, which extends from *Guinea* to the *West-Indian Islands*, is contracted by *Libration*, into half that Breadth of the *Atlantick Tumour* ; and consequently must be rais'd double that Height, to recompence in one respect, what it looseth in another ; especially being depress'd perpendicularly by the Moon, and in a more ample Measure nearer the *Equator*, than elsewhere. After that the Lines of her Pressure are mov'd obliquely and thinner scatter'd ; to make *six Foot*

of Water there, more than equivalent to *twice Six*, at the Middle of the *Atlantick*.

Again, the said Tumour, diffusing it self towards the *Coast of Europe*; That Part of it, which falls on the *Westerly Shore of Spain*, and *France*, on the one Side; and on the *Southerly Coast of Ireland* on the other; becomes still more contracted, to add *six Foot* more; and entering upon the *Soundings*, their shallow Botoms still advance it gradually, as they ascend; to superadd *six Foot* at least, before it enters the *Chops of our English, and Irish Channels*; being contracted as well in *Depth*, as *Breadth*, so as to make its *Total Elevation twenty-four Foot*, or *four Fathoms* compleat.

Or, be the Tide, in its Passage between *Brest and Kingsale*, advanced to what other determinate Height soever; yet all the several Floods of our *Irish and English Channels*, from *Dublin to Hull*; as also those of *France and Flanders*, from *Brest to Amsterdam*, must depend upon it as their *common Source*; so as to owe their Rise above it, either to the advantageous Reception into their *Ports*, or to the favourable Conveyance of their *Channels*, thither; so as to mount some of 'em ordinarily, to *thirty and forty Foot*; and others extraordinarily, to at least *fifty, sixty, and seventy Foot*: But the Question is, How those *Ports and Channels* may be fitly dispos'd for that Purpose?

The first advantageous Disposition for a plentiful Flood, is, that the *Mouth of the Channel*, which intromits it from the said general Source, be wide enough to fill up the

Ports which receive it, in due Time, before its Reflux takes it off again ; or else it falls short of the Height of the *common Tide* which leaves the *Port* so unsupply'd, that it stagnates, in some Measure, into a *Lake* that neither rises so high, nor falls so low, as the *Sea* it self at *Spring-Tides* ; while the *Neap Tides* seem to cease into Calm-water.

Next, to give the said Aperture a considerable Advantage, the *Sides* of the *Port* which receives the Flood, must mutually *incline* each towards the other, to contract its Tumour as it were, *Pyramidically*, from the *Base* whereby it enters in ample manner, to the *Vertex*, where it is perfected ; that the Weight of so much Water, put into Motion, may still push forwards its *gradually contracted* Stream with more Violence ; to make out in Height and Speed, what it looseth in Breadth : as happens in the *Downs* ; which lie at above three hundred Leagues distance from the Ocean and are choaked up with the *Goodwin-Sand* and withal invert the Current *Westward*, quite contrary to its former Course, thro' the Channel that convey'd it thither ; yet the Bay, by the Vertue of its *Triangular Figure* alone, contracting itself into the Mouth of the *Thames* sends up the River a considerable Tide, for at least twenty Leagues together.

Thirdly, Because quickness of Motion adds an equivalent Force, proportionably to the Weight of the Water which is moved ; and *Projectils*, are inclined to follow their first Direction ; every Deflection from it, must turn to the Tide's Disadvantage : Hence it is, that the Mouth of the *Seine*, tho' it adds a Depreciation

before proportionate to its other Advantages, of Ori-
 it fall and *Figure*, to furnish Water enough for a
 Tide contracted Tide ; yet, being entangled by its
 that serpentine *Windings*, to and fro, it advanceth
 Lake not up the River above *half* as far, as it doth up
 now, and arrone upon the *same* Advantages ; finding all
 e Neap along an *opener* and *straiter Channel*, which car-
 es it up into the Land *one Hundred and twenty*
 onside *miles*, without any Disturbance.

which But, to raise the Tide at *Bristol*, remarka-
 ne each y above *all* the afore-mention'd ; besides the
 umour id Advantages of *Breadth, Depth, Figure*, and
 e *Basis* ; the *Severn-Sea*, which brings it
 to the ether, adjoins to the Ocean, and opens *di-*
 Weigh ly towards it, to receive it in full Force,
 n, ma d give it no *deflecting* Check at its En-
 Stream nce ; insomuch that the Tide sometimes
 Heigh reacheth *sixty Foot* ; and upon the special En-
 : as ouragement of a strong *South-west* Wind, it
 above overwhelms the adjacent Country in a *De-*
 Ocean re, beyond Measure.

-Sands Yet, to exalt the Tidal Flood to its *highest*
 d, quic ch, after it is contracted to the Half, by
 Chan at *English Channel*, before it reacheth the *Cape*
 Bay, b St. *Malo's* in *Normandy* ; it is again straitned
 e, co the Half, e'er it reacheth the Bottom of
 Thame Michael's *Hill* ; and there, being pent up
 , for a Corner, and put to a peremptory Stop,
 without any *Inlet* of a *River*, to take off part
 n ad the Tumour, it swells to *twenty Foot* ; the
 to the *best* Tide perhaps, that can be found thro'-
 d ; an at the Universe.

first D Moreover, when *Two* Tides chance to
 ft tu eet, and are united in *One*, the joint Flood
 is, th comes exceedingly advanced ; the Speed of
 a Dep air Occurrence one towards the other, be-

ing accelerated in a double Proportion to the single Motion of each apart ; as is observ'd in the Congress of the *North and South Tides*, both in our *Irish Gulph*, at the *Peel* in *Lancashire* ; and at the *Mouth of Humber*, in the *German Ocean* ; where they amount to *ten Fathoms*, or *fifty-four Foot* apiece ; tho' it happen at their utmost Distance from the *Atlantick* ; and after the Flux of their Currents be almost spent into *Calm-water* ; yet without the Assistance of the aforesaid Advantages.

In fine, such is the gradual Encrease of the Tidal Tumour, as well in the wide *Ocean*, as in our narrow *Seas*, that one New-Moon Flood, runs thro' all the Diversity I have hitherto described, within the Space of *twelve Hours* ; in passing (for Example) from the *Equator* to *St. Malo's* ; insomuch that *six Foot* of Water in the one Place, is advanced to above *sixty Foot* in the other : And where it has been observ'd, that the *Equinoctial Tide* do not superadd to the rest, above *six Inches* to the *Line* ; yet at *St. Malo's* they surmount their Fellows at least *five Foot* ; the Product agrees exactly with the former Account, viz. that, as a Tide of *six Foot* there, produces another here of *sixty Foot*, in a *Decuple Proportion* ; so does the *six Inches* superadded make *sixty Inches*, or *five Foot*, which is the Number propos'd.

Thus the Tides are diversified in our *Rivers* and narrow *Seas*, with an endless Variety, both of Course and Growth successively, according to a regular Order, both of *Time* and *Place* with a constant Dependence on the Flux and



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flux of the *Ocean* ; and as received by our
Islands, and Ports, with open Arms : But now
to be treated, as being shut up in such
Gulfs, and Seas, as admit of more or fewer
Communications than ordinary, and sometimes without
Communication with it whatsoever.

C H A P. V.

Of the great Diversity of Tides, in our In-
land Seas, or Lakes ; and, How they are
occasion'd.

I Have hitherto consider'd the Course
of the Tides, and its various Ap-
pearances, as taking their first Rise,
from the Moon's Pressure upon
the Sea, near the Equator ; in-
much as they affect those Ports and Arms of
the Sea, which have a free Communication
with the Ocean ; and mostly ebb and flow to-
gether with it, twice in twenty-four Hours : But,
I now to confine my Discourse to such
Bodies of Water, as are Seas only by denomi-
nation, but Lakes in reality, for their little
Commerce with it ; and with regard to
these Tides also, which immediately proceed
from her Pressure and Presence, without any
dependence on the Ocean at all.

Now, forasmuch as those Lakes which lie
entirely sequester'd from the Sea, are differently
affected by the Tide, from those which en-
joy a free Communication with it : And ac-
cordingly, These become as diversely agitated by its
Ti-

Tidal Commotion, each according to their respective Correspondence with it ; and more or less, with regard to the Number and Capacity of the Passages which joyn 'em together. Hence, for Distinction and Clarity's sake, begin with those, whose Consideration is most simple, and separate from the Sea ; and proceed to the Rest, according to the Order of their Composition, which have One, or Two Inlets from the Ocean ; and shew how they are affected thereby ; and each in a distinct Section.

S E C T. I.

Concerning such Seas, or Lakes, as are wholly separated from the Ocean ; yet sometimes Ebb and Flow, by the Moon's immediate Pressure.

FIRST, the *Caspian Sea* is not obnoxious to any Tidal Commotion, as lying extended from North to South, athwart the Moon's Diurnal Course, which is from East to West ; so that her Pressure must affect its superficies, much alike in all Places at once, and cannot raise the Tide more in one Place than in another : Besides, being so shallow towards the West Side as scarce to be Navigable, it is not capable to receive a Counterpoise of Water, to fetch up the Eastern Part, which is much deeper ; that the whole Lake may librate reciprocally both ways ; the one End of the Scales, quite overweighing the other.

Next, tho' the *Euxine Sea* be of an equal Extent with the *Caspian*, and of a much more

the Commodious Situation, being stretch'd out
from *East to West*, that her Pressure may roll
over it successively ; yet it suffers so small a
commotion from it, either to set its *Libra-*
tion on foot, or to advance it gradually, as
force to render it perceptible ; for want of
; and *lining Shores*, to contract it into a narrower
compass towards the *East and West Ends*, and
open it both ways into a Point, as it does
the following Instances.

For, whereas the *Huron-Lake* in *North-Ame-*
is of the like Situation, and almost of an
equal Extent, with the aforesaid ; by being
contracted towards the *East End*, into a more
acute Angle ; it advanceth a Tide to so confi-
derable a Height, that twice a Day (by the
of its *Libration*) it swells the *Canada* more
than ordinary, for five or six Leagues toge-
ther.

Moreover, the *French* report of the *Upper*
River, which lies on the *N. West* of this, and
flows into the same River ; that notwith-
standing it is situated five hundred Fathoms a-
bove the Superficies of the Sea, and lies at
the distance of hundred and seventy Leagues from it ;
yet it Floods to two, three, and four Foot in
the Night ; which plainly shews, that these Tu-
rrents proceed absolutely from the *Moon's*
Influence, without the Intermediation of the
Sea, to raise 'em by way of *Libration*, at so
great a Distance from the Sea, and exalted so
many Fathoms above it.

And whereas my Author adds, that the *Up-*
Lake is a hundred Leagues in Breadth, and
proportions of a Length proportionate ; and sig-
nifies by Remarks, that its Tides advance to the
Heights

Heights aforesaid at the *Full-Moon*, without taking any Notice of the *New-Moon* Tide at all; he plainly implies, that either the happens *no* Tide of the later Sort; or that they be of a Size or Number much *inferiour* to the former: And *this Reason* is assignable for the Disparity; *viz.* That, altho' the *conjoin'd* Pulses of the Sun and Moon (at the *Change*) be equivalent to their *separate* ones (at her *Full*) in the *Ocean*, where the *Water's Volubility* is such, that 'tis all one whether their Pulses be *once doubly*, or *twice singly*, applied, within the Space of *twenty-four Hours*. Yet in *Lakes*, wherein, for want of a competent *Breadth* and *Depth*, the Tidal Tumour cannot *roll* to and fro with the same *Freedom*, their Pulses ought to be *repeated twelve-hours* (as at her *Full*) to give *every other* Vibration a jog, to keep 'em *on foot*; and not expect 'em to be *doubl'd* at the *twenty-four Hours* End, lest, by so long a Forbearance, they grow *sluggish* and *unactive*, as, by degrees, would to cease.

S E C T. II.

Of *Inland Seas*, which partake of the *Influence* of the *Ocean* by one *single Streight*, or *Passage*, and how *variously* they are affected thereby in reference to the *Tide*.

AS to those *Seas*, which have a *single Inlet* or *Course* with the *Ocean*; the *Balick* keeps a constant Correspondence of *Flux* and *Reflux* on

with the German Ocean, without any Tidal Influence from it ; sending forth a Stream of Water into it in Winter, when the fresh Floods well it above the Level of that Ocean ; and withdrawing it again in Summer, when the scorching Heat of the Sun sinks its Superficies much below it.

Besides, the Gulph lies in too crooked and awkward a Posture, to be wrought upon by regular a Motion, as that of the Tide ; and situated too far North, to be influenced by the Moon's immediate Pressure ; and withal so remote to the Eastward, and thick-shelter'd on the West by the Orca'de's Islands, to be influenced with a Tide from the Atlantick : But, on the contrary, the Mediterranean Sea, being situated more advantageously in the aforesaid respects ; as lying more to the South, and in the Tide's way ; and being of a commodious Figure, is as diversly affected, both by the Influx of a Stream from the Ocean, and the Impulse of the Tide.

In reference to the former Consideration, it allows down, by the Streight of Gibraltar, a vast Quantity of Water, without any competent Return ; and the Reason is manifest ; being most expos'd to be drain'd by the scorching Beams of the Sun, by means of its more southerly Position, than of any other Lake in Europe : And, on the contrary, being scarcely recruited by the Confluence of fresh Rivers, considering the Largeness of its Extension, and vast Tracts of Land, which it waters with its Vapours : as from Spain it receives only the Ebro, which is considerable ; from

from *France* the *Rhosh*; and from *Greece* and *Asia* only the Influx of the *Bosphorus*; which also has its Reflux at the same time; and from the Coast of *Africk* only the *Nile*, which is of any Account; the rest of their Streams (which are almost innumerable) being run off into the *Indian* and *Atlantick* Oceans without any other Gullet than this at *Gibraltar* to make Restitution.

And, to consider this *Midland Sea* with regard to the Impression of the Tide; since, as to its Position to the *Westward*, it enjoys free Communication with the Ocean, to be stirr'd up at every twelve Hours End by the Tidal Influence of the *Atlantick*, after the manner of other Arms of the Sea, which run directly into the *East*: And again, as to its Extent, it stretcheth itself *Eastward* about fifty Degrees, from the said *Streight* up into the *Levant*; and carries along with it a competent Breadth, to resent the Moon's immediate Pressure with a Tidal Commotion, like the *Lakes* aforesaid; which, in accord with her Diurnal Motion, must set into the *West*, in Opposition to the Former.

Now, in regard this *Midland Sea*, (at the End whereof the said two Tides are so differently rais'd,) consists of one entire Body of Water; they must, in some sort, interfere with each other: And again, the Moon makes her High-water at *Rhodes*, which lies near to the one End of that Sea (as appears by the Table) at her Southing there; and finds it the same again at her Southing, on the Road of *Gibraltar*, which is the other End; having pass'd fifty Degrees, or a Quadrant of her Diurnal Circle.

ce and into the *West*: Hence the said Tides must so
 which keep Touch with each other, as to rise and
 d from all by Turns at every *six Hours* End, and com-
 which pose one *single Motion*; the *whole Body* of
 trean Water *Librating alternately* from the one End to
 ng re the other.

Ocean To establish the *Union* of the said *Two Tides*
 Gibr One, by *Counter-libration*; the *Streight*, which
 is in the Former, being of too *narrow* an Ori-
 with ce, to receive and raise a Tumour sufficient to
 ; since reach the *Levant*; especially the Gulph being
 enjoys ear *stop't up* in the Middle by *Sicily*; which ma-
 , to nestly *divides* it into *Eastern* and *Western Bays*;
 by which lie not in one *Strait Line*, but disjoin'd
 iter d displac'd, each according to the different
 which irection of the *Shores*: Yet the Gulph is of a
 s to competent *Capacity* to contain, as it were,
 l about wo Tides so differently rais'd at both Ends of
 into at once; which have free Liberty left 'em
 comp for their *Conjunction*, and fall at a *correspondent*
 mmedi time, each to *advance* the other, according
 like its proper and natural Course, in reference
 with their joint *Libration*, quite thro'out the *Me-*
 , in *terranean*; as I have already described.

Besides, the Tides on both Sides of their *Axe*
 (at e le to near an *equal Height* in the *Eastern* to
 so e *Western Division*: Hence it is, that the
 Body ide rises as high at *Venice* as it doth at *Mar-*
 fare w lles; as also in the *Euripus* as at the Bottom
 n mak the *Levant*; in each reaching about a *Foot*:
 near d more signally to express its Dependence
 the T on the *immediate Pressure* of the Moon, it
 nds it ore abounds at the *Full* than at the *Change*;
 Gibrat cording to the Custom of *other Lakes*, which
 fifty old an immediate Correspondence with her
 l Circ esence: After all, it swells highest where
 it

it is *broadest* ; and higher on the *North-Side* of the Gulph whither it is driven, than on the *South-Side*, where it is taken off by a *Coasting Current* (according to the Course of the Ocean) into the *South-East Levant* ; whence came.

Now, to take the Liberty of Speculation on the Tide in the *Red-Sea* ; (having hitherto had a constant Recourse to Sense and Experience, for *Matter of Fact* in other Places) and to argue from *Parity of Reason* ; altho' it consists of a *long and narrow Body of Water* continued by a *Streight* to the *East-Indian Ocean* (much like the *Mediterranean* by that *Gibraltar*) which is almost choak'd up by *Island*, which obstructs its free Communication with that *Sea* ; yet it has a competent Tide by the Assistance of the Moon's immediate Presence ; lying stretch'd out, for near *twenty degrees*, from *South-East* to *North-West* ; in the most advantageous Posture for the Moon to affect it at the *South-East End* first, at her Rise and thence to push the Tide forward gradually towards the *North* and *West*, upon her Advance to the *Meridian* ; and as opportunity to let it fall back again *Eastwardly*, at her Declination into the *West*.

SECT.

S E C T. III.

Of those Gulphs or Lakes, which, by receiving their Tides thro' several Channels, either add or subtract from their accustomed Number, in other Seas.

SINCE amongst all the Diversity of Tides, which I have yet discours'd of, either in the Ocean itself, or our narrow Seas, High-Water does regularly affect the same Place, *once in twelve Hours*: It now falls of course to enquire, How it come to pass, that one and the same Tide sometimes flows *oftner*, and several distinct Tides *seldomer* than *twice in twenty-four Hours*: And to produce *Instances* respectively for that purpose,

First, It is observable, that *irregular* preternatural Tides (whether by *Excess* or *Defect*) affect only such *Gulphs* or *Lakes*, as are situated *between* two Seas; and those of the former Sort, which *exceed* in Number, are occasion'd by the *Division* of one and the same Tide into *several* Streams, by *different* Channels, conveying 'em thither at *diverse* times; where, notwithstanding their *Division*, if they chance to arrive both *at once*, they compose but *one regular* Tide, at their *union*; as plainly appears in our *Irish Gulph*, where our *North* and *South Channels* meet, and ordinarily *re-unite* their divided Floods into *one*; and alike communicate it to all the *confluent Rivers* around the *Shore*.

T

But,

But, in case the said divided Floods reach not the *Bottom* of the *Irish Gulph*, at the *same Time*; as is observ'd of the *biggest Equinoctial Tides*, when that Part which comes from the *South*, is driven thither *over-hastily* by a brisk *South-west Wind*, standing full into the Mouth of *St. George's Channel*; before the other Part can come up out of the *North* to join it, (the *same South west Wind* setting against it;) they become *supernumerary*, as well in the *River Lune*, as in the *Gulph* itself; which, the former Flood (coming sooner than ordinary) having fill'd with an *unusual Speed*, retires, and the *Later*, finding the Water fall'n five or six Feet, *re-advanceth* it as much higher than it was before; making *Two distinct Floods* in *three Hours Space*, contrary to the Custom of the *same Winds and Tides* in other Places.

Two New Tides that hap'n'd in the said *Gulph*, the Former in *October*, and the Later in *March, 1710*, were remarkable *Instances* of this Truth; in coming an Hour and Half sooner to the *Lancaster Sands*, by the *South Channel* than they were expected; and rising higher than was usual, being hurried thither by both *sterous South-westerly Winds*; and both fell, for half an Hour, to near *Half-Tide*; and then rose again, at the coming up of the *North Tide*, by the *other Channel*, five or six Feet higher than before; and continued half an Hour longer than ordinary, before they went off again; the *North Tide* having been so much retarded, by the *South-westerly Wind* from that adverse Quarter.

For *Ireland*, lying interpos'd between the *Ocean* and the said *Gulph*, where those Tides abound; and being separated on the *South*

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West from *Wales*, and on the *North-East* from *Scotland*, divides every Flood into *Two*, as they pass thro' their *several Channels* thither; where, if they arrive (as they commonly do) at *one* and the *same* Time, they are again re-united into *one Regular Tide*; or else, if the one be *hasten'd*, and the other *retarded* by the *same* Wind, or by any other Accident, they remain still *divided* into *two Irregular* ones; 'till their Return from thence into the *Ocean*, whence they came.

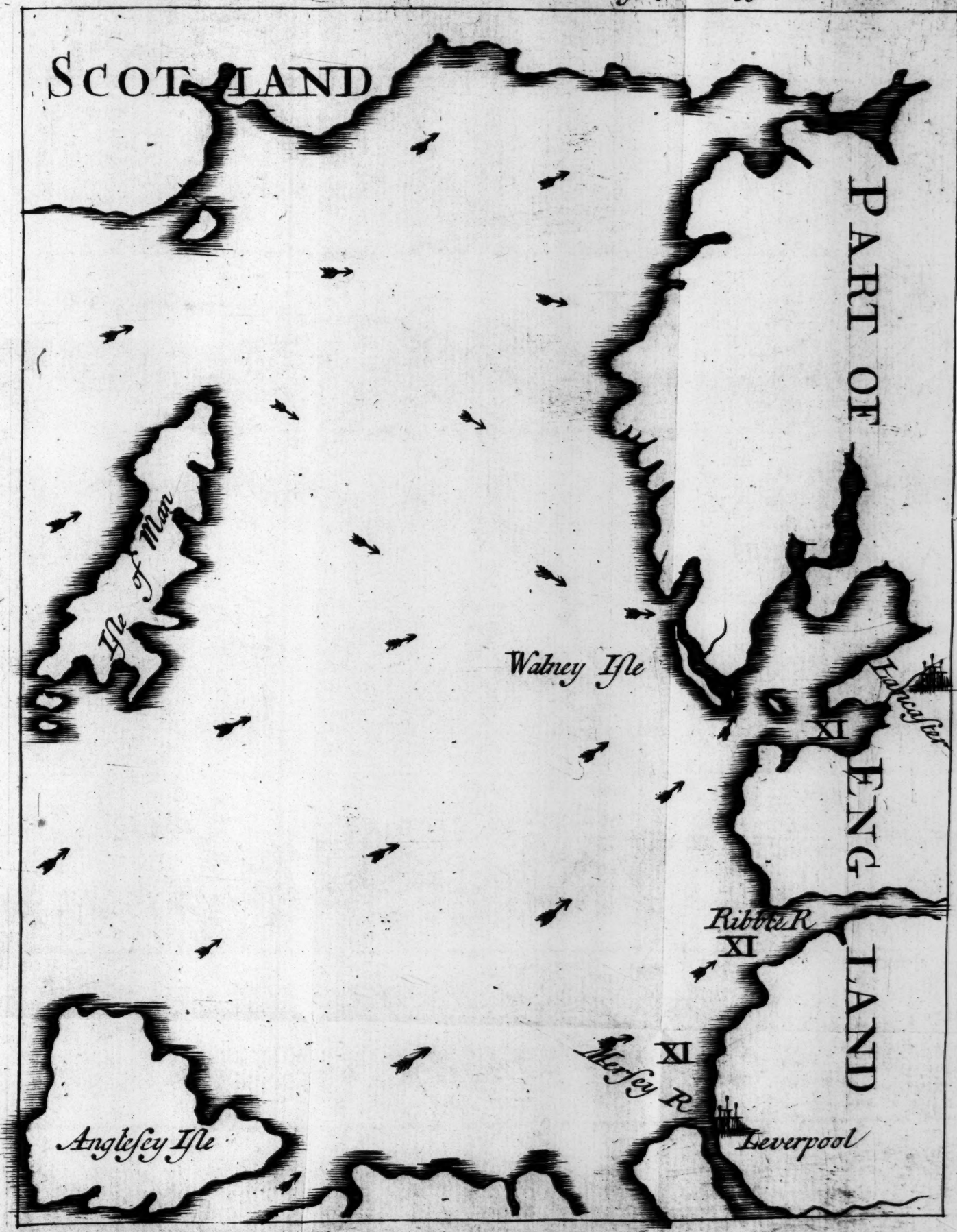
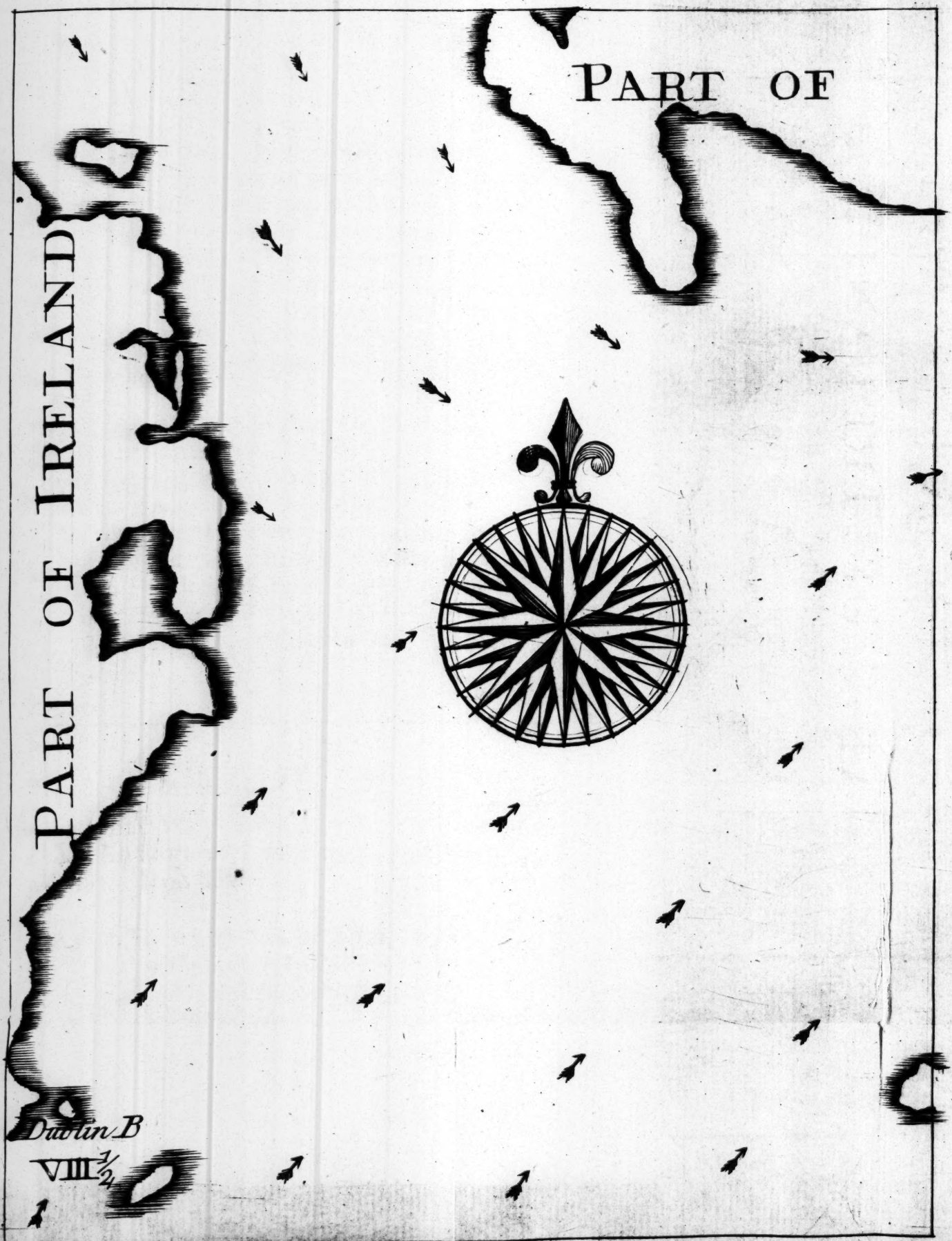
Now, in regard the *Isle of Walney* is alike interpos'd between the said *Gulph* and the *Channel* (or *Race*) which separates it from *Furness* in *Lancashire*; in case the Tide be *Regular*, so, as to swell up the *whole Gulph* jointly at once; it must enter the said *Walney Channel* at both Ends, at the *same* Instant; and consequently, their divided Streams meet in the *Middle* of the *Race*, and re-unite still into *one* *Regular Flood*, as was before: But contrawise, if the *North* and *South* Floods remain divided in the *Gulph* itself; they subdivide here into *Four* in *twelve Hours*; and if that Tempest, which first separates 'em, continues so long; they become again redoubled into *Eight* in *twenty-four Hours*, by a repeated Succession.

Because, *Walney* lying at the *Bottom* of the *Gulph*, and at an *equal* Distance from the *Mouths* of the said *Channels*; its *Race* stretching itself *seven Miles* in Length, and situated directly *North* and *South*; each Tide must respectively enter it sooner at the *one End*, than the *other*; so, as to make *each* its Fluxes in it, *apart*; that every *irregular Tide*, whether from the *North* or *South*, may make

Two of each Sort in this Gullet, for One in the Gulph itself: So that, when One Tide of the Ocean becomes Two in the said Gulph; those Two must be redoubled, in the Walney Race, into Four within the Space of twelve Hours; and these into Eight in twenty-four Hours, the same Means being repeated; as is manifest.

Hence plainly appears, how Tides may be multiply'd above their usual Number, in some Seas: Now, to shew how they fall short of their common Account in others; it was farther observ'd, that, altho' the said Gulph sent *Two* distinct Floods up *Lune*, as far as *Lancaster*; for *One* receiv'd from the Ocean by different Channels; yet at the same Time, those *Two* Floods re-united into *One*, in *Marshey* at *Liverpool*; notwithstanding both Rivers had an immediate Communication with the Gulph itself, because they comply'd not alike with its Tidal Agitation: For, the *Former* having a wide Aperture, and but a narrow Channel, was quickly fill'd by the *South* Tide, and soon emptied together with the Gulph: Whereas the *Later*, having contrariwise a large Pool to be fill'd, and but a strait Gullet to let it off again, cou'd not dispatch its Work, before the *North* Flood came up, to re-join 'em both into one single Tide; which stood to its full Height with scarce any sensible Diminution, for near *two Hours* together.

Thus one regular Tide of the Ocean, by passing thro' several Channels, with unequal Speed into the *Irish Gulph*, became *Two* irregular ones. Again, each of those *Two*, by entering *Walney*
Race



Race differently, were re-doubled into *Four*; while contrariwise, by *hasting too quickly*, the one after the other, into the Port at *Liverpool*, they re-united again into one, in *twelve Hours Space*; and by the *same Means* repeated, they wou'd have re-doubled in *twenty-four Hours*, their Number *Four* into *Eight*, at *Walney*; and *One* into *Two* at *Liverpool*: And moreover, had the *R. Marshey* been capable to contain, and reduce these *Two* last into *One*, at *twelve Miles Distance* up the River; there had been but *One Tide* at *Warrington*, in *twenty-four Hours*, for *Eight* at *Walney*; as is manifest.

Now, this being the present Condition of the Tide in reference to the *Euripus*, where it flows *Eight* times, for *Once* in the Port at *Tun-kin*: I am to shew how it is multiply'd in the *Former*, by the Interposition of *one Island behind another*; and in the *Later*, how it is reduc'd to a few, by the Position of *Ports*, lying in the like consequent Order; and declare expressly the *Manner*, how *both* are effected in the *Three ensuing Sections*.

S E C T. IV.

Of the supernumerary Tides, in the Euripus; and their Analogy with those which sometimes happen in our Irish Sea.

IN that *Gulph* which lies between *England* and *Ireland*, which hath *North-Wales* on the *South*, and on the *North Galloway* in *Scotland*;

it is observ'd, that, as *One Tide* in the *Ocean*, being divided into several *Streams successively convey'd* thither, makes *Two Floods*; and these, being subdivided by the *Interposition of Walney Island*, seem to become *Four Floods* in *twelve Hours*, and *Eight* in *twenty-four Hours*, within the *Streight* between it and *Furness* in *Lancashire*: So *One Tidal Tumour* in the *Mediterranean Sea*, in the same *Spaces of Time*, raiseth *Two* in the *Archipelago*; and *Two* here advance *Four* in the *Euripus*, by the *Interposition of Candia* and the *Negroponte*: Of which, that I may deliver the *Particulars* after a more special *Manner*, in the following *Sections*; let us first take a *View* of its common

DESCRIPTION, Viz.

" The *EURIPUS* is an *Arm of the Sea*,
 " between *Achaia* and the *Negroponte*; so nar-
 " row about the *Middle* of it, that it is pass'd
 " over by a *Bridge*: where the *Streight* is
 " broader, the *Tides* are more *regular* and con-
 " stant; for, in the *narrowest Part*, they are
 " regular *three Days* before the *Change*, and
 " *eight Days* after; and *one Day* before the
 " *Full*, and *six Days* after, and the rest irregu-
 " lar: During which *Time*, the *Euripus* Ebbs
 " and Flows *11, 12, 13, or 14 times* in
 " *twenty-four Hours*; but during their *regular*
 " *Motion*, they flow as *other Seas*.

" There are also *particular Differences*, be-
 " tween the *Tides* of the *Euripus*, and those
 " of the *Ocean*: *First*, The *Water* never rises
 " above a *Foot* high, and that very rarely too;
 " whereas in many *Parts* of the *Ocean*, it
 " rises

“ rises *twenty-four Cubits*: Secondly, That, in
 “ the *Ocean* the Water falls, when it ebbs into
 “ the *Sea*; and rises, when it rowls towards
 “ the *Shore*: Whereas the *Euripus* rises, when
 “ the Water ebbs towards the *Islands* of the
 “ *Archipelago*, where the Sea is broadest; and
 “ rises when the Water ebbs towards *Thessaly*
 “ into the *Channel* of *Salonichi*; altho’ it is ob-
 “ serv’d, that at High-water the Water stands
 “ still, without moving one way or other for
 “ an *Hour*, or half an *Hour* together: But the
 reason of this, no Man (*says the Author*) can
 unriddle.

Now, to draw a Parallel between the Situa-
 tion of the *Gulph* which divides *Ireland* from
England, as the *Archipelago* does *Candia* from
Greece, on the one Part; and of the *Channel*
 which separates *Walney* from *Furness*, as the
Euripus does the *Negroponte* from *Achaia*, on
 the other; in reference to the Tides produ-
 ced in all Four Places: Since they lie all open
 at both Ends, to receive their opposite Floods,
 either successively, or both at once: As often as
 they mutually occur in the Middle of their
 Channels, they unite each Two into One, at
 their Congress in the *Archipelago*; and re-unite
 again in the *Euripus*; as I have shewn they do
 in the *Irish Gulph*, and *Walney Race*; and have
 one single Tide apiece, in twelve Hours Space,
 as regularly as in the *Ocean* itself and *Mediterranean Sea*, whereon they depend.

On the contrary, at the Seasons of their
 Irregularity, when the said counterposing
 Floods arrive successively, one after the other;
 so as to make distinct Tides, at the Place First

design'd for their Occourse ; their several Streams must be subdivided at the Second ; Hence, as every single Tide of the Ocean, divided by the Interposition of Ireland into Two distinct Tides in the said Gulph, becomes subdivided by Walney Race into Four : So every Tidal Tumour of the Mediterranean Sea, being first divided by Candia, becomes Two in the Archipelago ; so afterwards subdivided by the Negropont, it is made Four in the Euripus, within the Space of twelve Hours ; and in twenty-four Hours, they double that Number.

Again, whereas the Ocean's Tide requir'd a S. West Wind, to carry the one Part of it down into the Gulph, before the other could arrive from the N. West, to keep their Floods distinct ; and each of these were differently directed into their respective Ends of Walney Race, to transmit their Floods into 'em at several times : In lieu thereof, it is observable, that the Mediterranean Tumour, in passing from the Streight of Gibraltar to the Levant, deflects that Part of it into the Channel which severs Candia from Morea, at a competent Distance of Time and Place, from the other which parts it from Rhodes ; for their Two Streams to produce, each a distinct Tumour in the Archipelago : And these, taking as different Courses towards the Euripian Streight, the one being so much shorter and more direct than the other, that their different Allowances of Time is doubl'd before they reach it ; to subdivide their Tumours here, and subdistinguish 'em each apart, no less than those did before in the Archipelago, without interfering in any respect with one another.

And

And if those *North* and *South* Streams, which flow from the *Ocean* into the *Irish Gulph*, seem to come thither as it were by *Pairs*; and haste soon the one after the other, to make distinct Tides after an *Hour and a half's* Ebb, either there, or in *Walney Race*; the *Mediterranean Flood*, to make amends as to that Part of which first enters the *Archipelago*, finds a shorter and readier Passage at the *West End* of *India*; while the Remainder traverseth the *South Coast* of the *Island*, above *thirty Leagues* out of its way to the *Eastward*, before it descends into the said Sea; and every Flood here, being subdivided by the *Negroponte*; that Subdivision, which enters the *Euripian Gulph* at the *South End*, finds as short and direct a Passage, as before; while the other has the whole length of the *Negroponte* to pass, and to repass the *half Way* back again, by a narrow and difficult Gullet, before it reaches the *Streight*; to rejoin its *Compartment*, which was retired before it advanced thither; so as to have a full Allowance of *Time*, to make a fresh Tide at every *three Hours* End.

And, forasmuch as the Tidal Tumours in the *Archipelago* are scarce perceptible; yet their depending Floods are distinct enough in the *Strait of Euripus*, as entering alternately, at the Distance of the Time aforesaid: That from the *South*, by a Channel of a wide Aperture, which contracts it gradually almost into a Point, give it Height in the *Streight*; while the other from the *North* makes use of the like Advantage, to raise its Water above the *Archipelago*, their common Source: And, on the contrary, tho' the Tides run very high in the *Irish*

Irish Gulph, as being influenced immediately by the *Ocean*; yet they are scarce distinguishable in *Walney Race*, because of the Shortness of its Channel, and the sudden Hurry of Streams thro' it; which, for Number of Flux and Reflexes, are the same with those of the *Euripus*, tho' without the like Tidal-Distention.

Especially, in regard the said Irregularity proceeds, in the *Irish Gulph*, from an excess Flood hasten'd by Storm; which never happens, but at Change and Full, and most when the Moon is at her Equinox: But the Multiplicity of the Tides in the *Euripus*, is constantly at her Wane, thro' Defect of Water when the South Tide cannot hold out its Course, 'till the North Flood comes up to join it: So that both fall back irregularly before their Union; which happens periodically twice every Month, and for several Days together. Whereas in our *Western Gulph*, those Spring Tides are separated by Anticipation, and occur accidentally, but twice or thrice a Year, when the Wind proves favourable to the one Stream and adverse to another.

Yet, whether the Tide's Irregularity proceeds from an Excess or Defect of Water; the Regularity still supposeth a perfect Re-union of the Tide, to succeed in the same Place, after every Separation: And as often as several Places depend each on other; the Re-union in the later Place, still supposeth an Union of the Tides in the former: Hence, the regular Tide in the *Euripus*, must presuppose the Union of the two preceding Tumours, in the *Archipelago*; and this to be caused at the Full and Change.

When both the Sun's and Moon's Concurrence, Southing upon the *Levant*, falls in with the Ocean; and more especially at the *Change*, when they *South* there both at once, jointly to force their Meridian Pressure.

And the better to unite Two of those Tumours into One, when the Pressure is considerably encreased, it stirs up a *Libration* in the *Levant*, from *South* to *North*, transverse to that which is deriv'd from the Ocean, which is from *West* to *East*: And this moving alternately backward and forward, all at once, is apt to retard the first Tumour, and hasten the later, the same *Undulation*; and these so united are enabled to raise a correspondent Tide in the *Euripus*, to continue at the same Height an Hour together: Whereas the irregular divided Floods, rise and fall at the half Hour's end, without the mutual Support of each other.

And, forasmuch as the Channel to the Southward of *Candia*, affords a shorter and easier Passage, and points more directly towards the *Euripus*, to transmit a stronger and swifter Flood into the *Archipelago*; the other, which traverseth the Length of that Island, being it diverts into it, can only be a slow and weak one on that Account: Yet the Moon's Southing upon the Mouth of the *Eastern Channel*, and enforcing her rising Pressure gradually thereon, from the *S. East Levant* for one hundred and fifty Leagues together, must suffice to equalize its Flood with the former, in the *Archipelago*; and consequently to raise four equal Tides in the *Euripus*, in the first twelve Hours of her Presence, to enforce it.

Yet

Yet in the *next twelve Hours*, after her Departure from our Hemisphere, that second deflected Arm of the Mediterranean Tide, being deprived of her present Assistance, is there disabled for raising its Tumour in the Archipelago, to its former Height: Again, this Tumour being subdivided by the interposing Isthmus of the Euripus, before it enters the Euripus; her that Branch of it, which deflecteth again the Northward, and is to return into the Sea by the aforesaid narrow reflex'd Gullet, languish away into a Faint, and become imperceptible, before it reach the Streight itself. So that these Three remaining Tides, being added to the other Four, compleat the Number of Seven; which are all that can possibly be incident to the Euripus, according to the vulgar Account.

So close does the Parallel between the Seas, and their respective Tides (all Circumstances duly considered), hold to conclude that Two regular Floods, and Seven irregular ones, are incident to the Euripus, at their several Seasons; tho' caused originally, by the regular Impulse of the Mediterranean Sea, which flows but twice in twenty-four Hours: And the great Diversity of the Means WHERE and of the Manner HOW, the same Work is differently wrought; is so far from lessening the Validity, or obscuring the Evidence of the Effect, on either Part; that their Differences (as Light and Darkness counterpos'd) once mutually confirm, and illustrate each other to Perfection: Let us now accord

and Diversity of the *Euripian* Tides amongst themselves, with those of *other Seas*.

S E C T. V.

Observations upon the Diversity of Tides, in the Euripus ; and how consequent it is to my precedent Discourse, of the Tides in other Seas.

HAVING already stated the Number of the Tides, in the *Euripus*, according to the Evidence of Reason, and Experience; it now follows of course to enquire into the Means, and Manner of their Diversity; with the Respect to the Terms, and Tenour of its former Description; to shew how it squares with the Principles, I have already laid; and the Method I have follow'd thro'out my Discourse on the same Subject.

First, It is observ'd, That the Tides are regular about the Full and Change of the Moon, and become irregular at her Wane; because at her Change and Full, when they flow in ample manner, the South-Tide becomes both quicker, and lasteth longer; so as to hold out Flowing, till the North-Tide can arrive by the other channel, to join it; as well in the Archipelago, as in the Streight of the *Euripus*; in both which Places, they make but One regular Tide, consequent to the *Mediterranean*; whereas in her Wane, for want of a sufficient Supply of water, the former Tide retires, before the latter can come up to join it; so as to make

Two

Two separate Tides, in the *Archipelago*; which being again *subdivided* in the *Euripus*, make *Four* irregular Tides; as is manifest.

Secondly, Their *Regularity* continues *four* Days longer at the *Change*, than at the *Full*, which must needs proceed from a greater Depression made upon the Sea, by the joint Operation of the Sun's Light, and Heat, with her Pressure at their *Conjunction*, than at the *Opposition*; when their Forces are separate and cannot at once affect the *Mediterranean*.

Thirdly, The *Terms* of their *Regularity* begin but *two* or *three* Days before the *Change* and *Full*, when the Moon's Influence is at its *Height*; and yet continue for *six*, or *eight* Days afterwards; which plainly shews, that the *Mediterranean* Tides, are not forced to their competent Height, point-blank, by the direct Impulse of the Moon; or by the first Push of the *Atlantick* Flood, thro' the *Streights*; but are rais'd only by *Degrees*, with the Assistance of *Reciprocal Librations*; which find the Sea along, from thence to the *Negroponte*, more quiet and compos'd; and so they must be often repeated, before its Motion be considerably heighten'd, at so great a Distance; which again requires a proportionable Time after, to abate again into its former Irregularity.

Fourthly, The Water in the *Euripus*, never rises above a Foot, and that very rarely too; whereas in many Ports of the Ocean, it rises to *twenty-four* Cubits; because those Ports receive their Tides, with Mouths wide open, immediately from the Ocean, their common Source. But, on the contrary, the *Euripus* derives its Flood, in part from the *Atlantick*, thro' the

which *Straw Gullet* at *Gibraltar*; and down the *Mediterranean*, for *three hundred Leagues* together: and in part from the *Moon's Impulse* upon that *Sea*, where it wants the *Breadth*, and *Depth* of the *Ocean*, to raise its *Undulations*: So that 'tis a wonder, if every *Cubit* languisheth into half an *Inch*, before it affect the *Negroponte*, at so vast a *Distance*, and *Disadvantage*.

Fifthly, In the *Ocean* the *Water* falls, when it ebbs into the *Sea*; and rises, when it rowls towards the *Shore*; whereas the *Euripus* rises, when the *Water* ebbs, either towards the *Sea* or *Shore*, indifferently; and can do no less, than making a *Thorowfare Channel* for *Two* opposite *Tides*, to pass and repass thro' the *Streight*; where they never arrive exactly at the same time; and that which advanceth first, mostly arrives, before the other attain to its full *Height*: so that the one *Flows*, while the other *Ebbs*, either towards the *Land*, or *Sea*, respectively.

Sixthly, It is observ'd, that at *High-water* the *Water* stands still, without moving any way for an *Hour*, or half an *Hour*, together; that is to say, the *Water* stands still only for half an *Hour*, when the *Tides* are irregular; the *Tide* still returning, before the other be advanc'd to join and support it: But if they be regular, the supervening *Tide* always keeps the other up, at least half an *Hour* longer: when the *South* and *North Atlantick Tides* meet upon the *Equator*; the *Former*, which arrives an *Hour* and half sooner, is kept up by the *Later*, to its full *Height*, for near *three* *Hours* together.

Lastly,

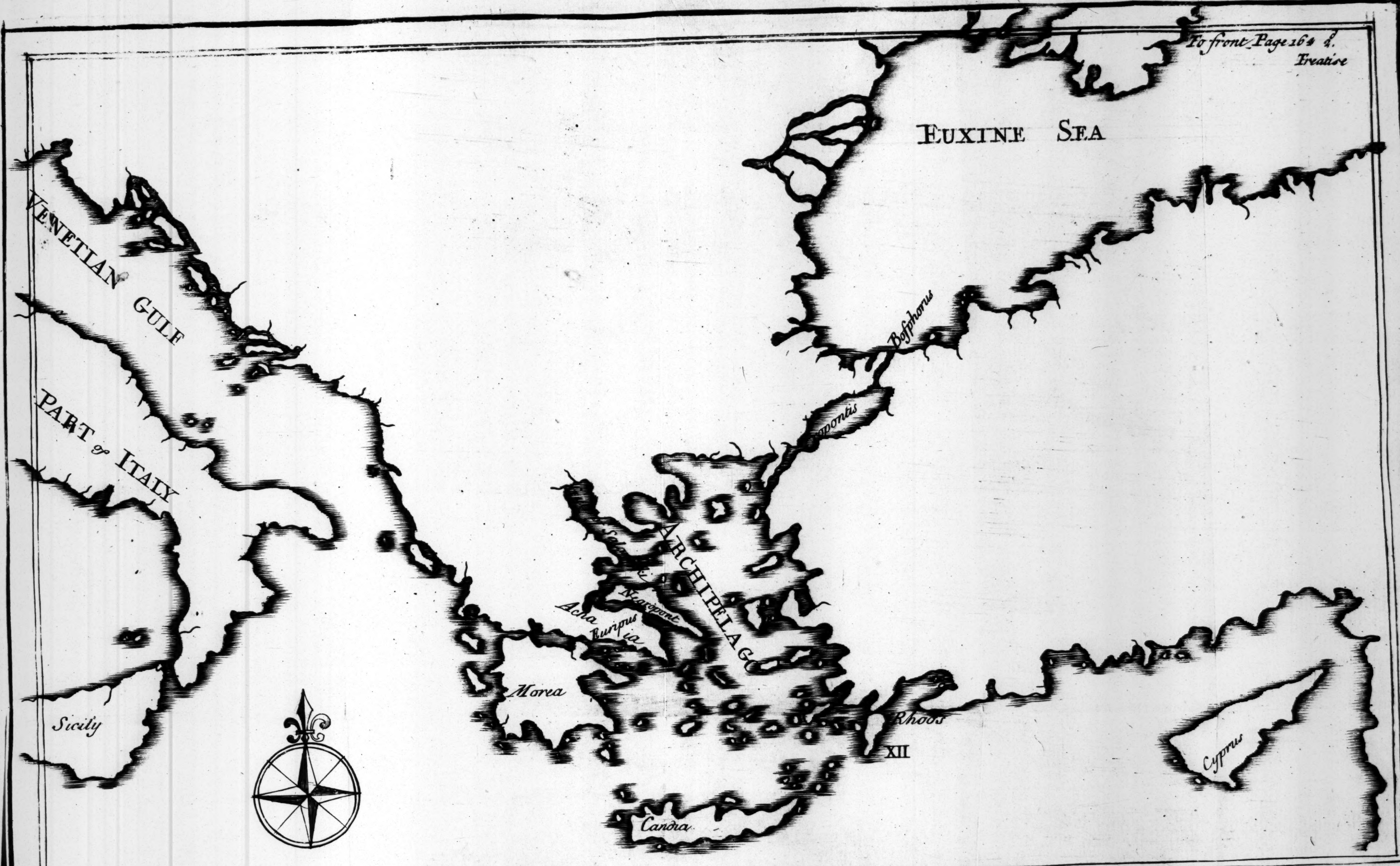
Lastly, During the Time of their irregularity, the *Euripus* ebbs and flows 11, 12, 13, or 14 times in twenty-four Hours; doubtless, depending upon the various Influence of the Sun and Moon; according to their different Aspects, between their Conjunction and Opposition; besides the Change of their Latitude and Variety of Distance from the Earth; which must make as various Tides, both for Number and Proportion.

And it is no wonder, that this Irregularity shou'd rather appear in the *Streight* of the *Euripus*, than in any other Sea, being so contriv'd by the Great Architect of the Universe; as if on purpose, to hold the Ballance of the Two opposite Gulphs, with so equal a Hand, as to turn the Scales, upon every Inch of Advantage, on either Part, and is placed so commodiously, on the Backside of *Achaia*, as to weigh the various Tumours of the Archipelago, upon the least Commotion, which way soever they approach it, as they pass by; while the Tide after so long a Course, as from the *Streight of Gibraltar*, is in so faint and languishing a Condition, (as in no other Sea,) to be scarce perceptible.

§.

Remarks upon the Observations aforesaid.

To sum up the whole Account I have given of the Tides of the *Euripus*, and the Reasons for them, in reference to those I have already observ'd in the Ocean, and discuss'd thro' my precedent Discourse; in order to confirm them



EUXINE SEA

VENETIAN GULF

PART of ITALY

Sicily



ARCHIPELAG

Morea

Rhoos

XII

Candia

Cyprus

by a Rehearsal of some Passages here and there, and *comparing* them together.

First, It is to be noted, that the *Mediterranean* Tide, according to its *common* and diurnal Course, always produceth *irregular* Tides in the *Euripus* ; as falling short of a *competent* Height, either *there*, or in the *Archipelago* ; as I have all along taken notice.

2dly, That, to reach its *regular* Height, its *Menstrual* Course is advanced, by the joint Concurrence of the Sun's Influence (as in the *Ocean*) with the Pressure of the Moon ; both upon the *Equator* *mediately*, and *immediately* upon the *Levant* ; as hap'ning constantly about her *Change* and *Full*, when they concur as aforesaid : Yet,

3dly, Their Influence works *more effectually* at their *Conjunction*, in the *Presence* of them both, than at their *Opposition* ; when she is *absent* from our Hemisphere ; when the *single* Impulse of the *Atlantick* must do the Work ; hence, there are more *regular* Floods at the *Change*, than at the *Full*.

4thly, The *Term* of their *Regularity*, beginning but *two* or *three* Days before the *Change*, and *Full*, when the Pressure is *greatest* ; and, continuing *six*, or *eight* Days after ; plainly demonstrates, That the Tides are *not rais'd* to that Height, neither *here*, nor in the *Ocean*, by the meer Dint of their Impulses ; but as *assisted* by repeated *Librations*, which are neither *soon rais'd*, nor *soon allay'd*.

5thly, Notwithstanding all those *Advantages*, even the *Regular* Tides never rise above *Foot* in Height, for want of the *Sea-room* of the *Ocean*, to rowl in *Latitude* from Pole to

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Pole ;

Pole; or in *Longitude*, from the *Streights*'s *Mouth*, to the *Bottom* of the *Levant*; without being interrupted by the *Interposition* of *Sicily*, in the very *Middle* of its *Course*; where the awkward *Devarication* of the intervening *Passage*, *breaks its Force* to almost nothing, before it can reach from one *End* of the *Mediterranean* to the other.

6thly, Nor were it possible, that the *Tide* shou'd be kept on foot, for *six hundred Leagues* together, by the *single Impulse* of so narrow a *Gullet*, the *one way*; did not the *Moon's Influence*, alternately push it again the *other*, at least *once* in every *twenty-four Hours*; which it constantly does, from her *Rising* till her *Setting*, at the *Road* of *Gibraltar*: Much less cou'd it raise the *Tide* higher at *Venice*, beyond *Sicily*, which *obstructs* its *Course*; than at *Marseilles*, on this *Side that Island*; did not the *Moon* influence it as powerfully on the *East Side*, as the *Streights* do on the *West*; and this also not by *Attraction*, but by *Pressure*; since the *Tide* is *driven* all along, upon the *European Coast*, and not *drawn* towards the *African*; and is rais'd to the *greatest Height*, where the *Sea* is *broadest*; as between the *Bottom* of the *Venetian Gulph*, where the *Tide* most *abounds*; and the *African Shore*, where it is *scarce perceiv'd* at all.

Finally, Nor cou'd the *Variety* of *Flux*, and *Reflux* be produc'd, without the *special Contrivance* of the *Sea's Situation*, for that purpose: As, to *divide One Mediterranean Flood* into *Two*, by a *Two-fold Passage* into the *Archipelago*; and again to *subdivide* these *Two* into *Four*, by the *same Means* in the *Euripus*, while the

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the Water keeps *low*: And, on the contrary, upon its *Rising*, to *rejoin* those *Four* into *Two*, and re-unite those *Two* into *One*, after their Separation.

So little does the *Diversity* of Tides, found in our *narrow* and *shallow Seas*; and much less the various Fluxes, and Reflexes of the depending *Rivers*, argue any *Irregularity* of Motion in the *Ocean* itself; or the least *Deviation* from the Intercourse of the Sun, and Moon, which I have *already* described; but merely proceeds from some *Inequality* of the Passages and Shores, which *hastens* or *retards* their Motion; or Disproportion in the *Situation* of the Place, that gives them as *different* a Reception.

Nay the *Euripus*, which for its *Multiplicity* and *Variety* of Tides, has been hitherto an inextricable *Riddle*, to puzzle and perplex all Mankind; is so far from laying any *new Difficulty* in our Way; That, when its *Situation*, and the Motions of the Tide consequent thereto, are duly consider'd; it proves to be a very favourable and explanatory *Instance* and *Example*, of what I have discours'd upon this Matter, in other Places.

S E C T. VI.

Of the small Number of Tides in some other Places; and Why, in the Port at Tunkin, there happens but one Flood in twenty-four Hours; and twice each Month, no Tide at all.

SINCE the Plurality of Tides, above the usual Stint (as I have shewn) proceeds from the like Number of Channels, dividing 'em as they successively pass into the same Gulph, or Port: And, on the contrary, their Paucity is occasion'd by as many Gulphs, still contracting distinct Tides, and those also deriv'd from different Seas, into half their Number: And since I have made it plain, how the common Tides, which constantly affect other Seas, but twice in twenty-four Hours, become doubled in the Irish Gulph, and redoubl'd in the Euripus: It now remains, on the contrary, to produce a Parallel Instance, wherein Four distinct Floods, and those also proceeding from diverse Seas, are daily join'd into Two, and these subjoin'd at last into One; and this also, is sometimes intermitted: And in order to shew, by what Means it is effected; take here, what is reported of the Port at Tunkin in China, for Matter of Fact:

“ In the said Port, there is but one Flood
 “ and Ebb in twenty-four Hours; and twice
 “ in each Month, (*viz.* when the Moon is
 “ near the Equinox) there is no Tide at all,
 “ but the Water is stagnant; but with the
 “ Moon's Declination there begins a Tide,
 “ which

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" which is greater when she is in the *Tropical*
 " Signs; only with this difference, that
 " when the Moon is to the *Norward* of the
 " *Equinoctial*, it flows when she is *above* the
 " *Earth*, and ebbs when she is *under* it; so,
 " as to make High-water at Moon's *Setting*,
 " and Low-water at Moon's *Rising*: But, on
 " the contrary, the Moon's being to the
 " *Southward*, makes High-water at *Rising*,
 " and Low at *Setting*; it Ebbing all the
 " Time, she is *above* the *Horizon*; as appears
 " more at large, *Philos. Transact.* Numb.
 " 162.

To disclose the *Cause* of this odd Appearance of the Tide at *Tunkin*, with regard to what happens of the same Nature in the *Irish Gulph* and the *Euripus*; it is to be noted, that these three Arms of the Sea are stretch'd out from *North* to *South*, and lie open at both *Ends*, to receive their respective Floods; which here at *Tunkin*, are propagated from different Seas; by the *North Channel* from the *Pacifick*, and on the *South* from the *Indian Ocean*: But what is more remarkable; at the *Middle* of the *Gulph* (where these Floods meet), lies open a Bay of a vast *Extent*, to receive 'em, and to carry their Streams to the *Port*; where they make but one Flood and Ebb in *twenty four Hours*; and the Manner how this is effected, is what I now undertake to describe.

As for the *Manner* of their Concurrence, instead of hitting an exact Time for their Conjunction, the *South* Tides arrive not 'till *six Hours* after those out of the *North*; the *Indian*

Irregularity of some Tides,

Ocean, whence they are propagated, lying at least *seventy Degrees* to the *Westward* of the *Pacifick*: Besides, the *Molucca's*, which they are to *traverse*, must be no small Impediment, to *retard* their Journey thither: So that their Floods must reach the *Gulph* *successively*, one after another, at *six Hours* Distance: Yet, in regard *each Two* of the same Sort, have their respective *North* and *South-Passages*, for their Entrance into it; and come no oftner than *Twice*, within the Space of *twenty-four Hours*; they have *twelve Hours* apiece, to make their Fluxes and Refluxes, forward and backward, as compleat as in *other Seas*.

But all *Four* Floods, when they reach the *Middle* of the *Gulph*, being of course to enter into the Mouth of the *Bay*, *successively* at *every six Hours* End; and it being a *Lake* of a *vast Extent*, and *horizontally Level*; their recurring Ebbs cannot make *so quick a Return* out of it, as not to stagnate: Besides, one Flood still *overtaking* another, e'er it be *half* spent, the Water in the *Bay* must *rise all the while*, and swell up a *Tumour* in the *Port*, which lies in the *Bottom* of it, 'till it reach a *determinate Height*, which cannot be *surpass'd*; and must stand *mounted* to that advanced Pitch, as long as their united Forces continue *equal*, to support it *alike* all the while; as it happens, when the Moon is *near the Equinox*.

But the State of this Topping Flood being *violent*, so as to raise the Water in the *Port* above the *Bay*, and in the *Bay* above the *Gulph*, and in the *Gulph* above the *natural Level* of the *Oceans*, whence they proceed; and is raised by some *Two* of those Floods, which chance

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to over-power their Fellows ; this surpassing Height of Water, must ebb off again on the weaker Side, in as long a Time as it was in rising ; that is to say, in twelve Hours apiece : So that all four concur to make but one Flood and Ebb in twenty-four Hours ; as is manifest.

Now, to assign which two Tides must be predominant over the other, with regard to the Situation of the said Port : Since it lies eighteen Degrees to the North of the Equator ; the North Tide, must needs be Superior : Again, forasmuch as the Primary Tides must exceed the Secondary Ones, the Primary North-Tide must be Supream : And, seeing the Port lies between the Tropicks, the said North-Tide must make High-water at the Moon's Setting (as it actually happens at Tunkin), as being the Result of the Ebb which she had caused by her Pressure, at her Southing upon the same Meridian.

Again, the Secondary North-Tide must needs exceed any that can be rais'd in the South ; in regard the Pacifick Ocean, whence it is propagated, coasts the Gulph all along upon its North, and East Quarters ; where it finds Store of Inlets to receive it, which are both short and direct : Whereas those from the Indian Sea come farther off ; and, having the crooked Windings of the Molucca Streights to traverse, are half spent before they arrive : Besides, this Secondary Tide, hap'ning twelve Hours after its Primary One, falls at a right Time to work the same Effect in the Port, by the Concurrence of its Associate out of the

South, at the *Rising* of the Moon, that its Competitor did at *Setting*.

Now, to state the respective *Efficacy* of their *mutual Concurrences*, as they make one circular Revolution, according to their *six hourly Succession*, as I have already described; it is remarkable, that, whereas the *Primary North-Tide* has but the *Secondary One* out of the *South* (which is the last and *weakest* of that Order) for its Partner: This *Secondary North One*, has the *Primary One* out of the *South* to precede it, and fill the Bay pretty full, before it arrive; to raise it at least to an *equal Pitch*, with its Competitor; that both jointly may hold the *Water's Equilibrium steady*, and the Tide in suspense; while the Moon stands Neuter, near the *Equinoctial*; as it actually happens in the said Port twice every Month.

But upon her *Declination* the Tide rises; and if she decline towards the *Norward*, the *Primary Tide*, on that Side of the Equator, being more enforced by her Pressure, makes High-water at her *Setting*: But, repassing the *Equinoctial Southward*, the *Secondary North Tide* (which hap'neth at the twelve Hours End) thro' the more favourable Assistance she gives the *Primary South Tide*, its Associate, on the contrary, shifts the Tide from her *Setting* to her *Rising*: And the nearer she approaches to either *Tropick*, the respective Tide becomes more advanced; and that One joint Tide, being compos'd of all Four; Two to Flood it up into the Port, and Two to Ebb it out again; each Flux and Reflux must continue twelve Hours apiece; which gives

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Such have been the *various* Phenomena of the Tide, thro'out the *Ocean*, according to my best *Information*, as I have described; yet one of 'em has thwarted the Doctrine I have deliver'd upon that Subject, in the least: and so much they have been *diversify'd* by the occurring *Coasts* and *Shores*, and their *In-* within Land; that, upon sight, they appear'd universally *Anomalous*, in some respect or other; yet still have fairly accorded with the Principles I have here laid, and the Use I have made of 'em: But as for their *Paucity*, *Plurality* in any Arms of the Sea, I found that appear'd, upon sight, so *odly* extravagant as the *Euripus*, and the *Port at Tunkin*; nor any that prov'd more suited to my Purpose, and *regular*, upon a due *Examen* of all their Circumstances, thro'out the Universe.

S E C T. VII.

the various Floods and Currents, found in the Magellanick Streight, of the Bosphorus, and at Gibraltar; Their several Causes; and the Manner how they are occasion'd.

SINCE I have shewn already, what Tides have been occasion'd in the *Gulphs* several Seas, by their Floods passing thro' *Streights* and *Passages*, differently affecting them: It now occurs farther to demonstrate,

monstrate, what Floods and Currents are found in those Streights; when they mediate join as different Seas; as, 1. Either Two several Oceans; 2. Or Two Inland Seas; or else 3. One of the one Sort with another of the other.

It is generally observ'd, that the Stream which most constantly affects any of the Streights, still descends from a higher Situation to a lower: Hence it is, that the *Anian* and *Molucca Streights*, which, in the North, connect the *Pacifick* with the *Tartarian*; and the South, with the *Indian Ocean*; as also the *Magellanick Frith* does the *Ethiopick* with the *South Sea*; all three Currents descend Westward from Oceans rais'd and push'd forward by the Easterly Wind, into a lower Water: As, on the contrary, the Stream, at *Gibraltar*, descends into the *Eastern Mediterranean Sea*, draining a lower than the *Atlantick Ocean*, by the scorning Beams of the Sun; and the *Bosphorus* descends from the Higher *Euxine* (swell'd with the *Danube*, *Boristhenes*, *Tanais*, &c.) into the *Lower Archipelago*, which receives not a proportionate Recruit.

Now, as to those Streams, or Currents, which are peculiar to the Streights of every Sort; and, for Brevity's sake, to single out One of each Kind, which is most remarkable for the great Diversity of their Floods:

First, The *Magellanick Streight*, which connects the *Ethiopick* and *Pacifick Oceans*, besides its constant Stream into the West, has also a Tide that sets in with it, which rises and falls

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very six Hours, with about twelve Minutes Interval, as in other Seas: And a contrary Tide, from the *Pacifick*, falls into the Mouth of it the *West End*, which contracts itself narrower towards the *East*, for thirty Leagues together; 'till the *Gulph* become straitest, and the opposite Floods grow sharpest, when they chance to re-encounter near it.

So that the *Passenger*, to render this *Gulph* navigable, avoids the falling in with their *Occurrence*, where the Streight is narrowest; by timing the *First* of his Tide, to bring the Vessel into it, and carry her thro' it, before she meets with the *Adverse Flood*; that the Channel becoming re-enlarged, (the One being not much contracted, nor the Other relax'd,) the occurring Streams may swell up gently to calm and smooth Water: so that, if a brisk Gale favour the Ship's design'd Course, she may bear up against the Stream, either to the East or West, so as to make the *Voyager's Passage* quick and safe: Infomuch that the good Success of some, who Timed and Tided the passing this *Gulph* aright, have discredited the dismal Reports of others, as feigned and fabulous.

But, Mr. *Dampier* found 'em much otherwise; who tells us, That after his Ship was driven into the Mouth of *Le Mair's Streight*, which is near the *Magellanick*, but much less difficult and dangerous) " They found a strong Tide, setting out of the Streight to the Northward, and like to founder the Ship; but whether Flood or Ebb, they knew not; only it made a short cocking Sea, as if it had been a Race, where two Floods met, for it

" ran

“ ran every Way : Sometimes breaking in over
 “ their Waste, sometimes over their Port
 “ sometimes over the Bow, and the Ship to
 “ like an Egg-shell ; so that they never
 “ such uncertain Jerks in a Ship : And be-
 she fell in with the occurring Floods, where
 Passage was straitest.

Secondly, As to the Bosphorus, which, though
 be a Streight between two Inland Seas, without
 any Connexion with the Ocean, or Dependence
 on its Tide ; yet 'tis obnoxious to
 great a Diversity of Currents, which proceed
 from different Causes.

1st, Concerning that Current, out of the
 Euxine Sea into the Archipelago, from North
 South, it necessarily descends by the Propensity
 of its own Weight (having neither Wind nor
 Tide to drive it) ; and consequently it descends
 from a higher Station, to a lower ; the
 Euxine overflowing the Archipelago, as being
 Proportion replenish'd and swell'd by the
 Tanais, Boristhenes, &c. more plentifully
 than the Mediterranean Sea, which exceeds
 it at least thrice its Compass.

2dly, Whereas the said Stream is but six
 deep, and floats upon a contrary one out of the
 Archipelago, which preponderates it, as is found
 by sundry Experiments ; 'tis no more a Wonder,
 that it floats upon the Surface of the reverse
 Current, than that Oil swims upon the
 Surface of other Liquors.

3dly, Nor is it more strange, that the Sea
 and consequently the denser and heavier, Water
 of the Archipelago, should force its Way
 under the Euxine Stream, into the North by

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reponderation (which is *freſher* and *lighter*, and ſo leſs able to *reſiſt* it): And the nearer ſinks to the *Bottom*, ſtill it becomes more *ponderous*, and enabled to *preſs forward*, in Proportion to its Weight upon a deeper Deſcent; ſpecially about the *Middle* of the Channel, where the *Counter-floods* have Liberty to exert the Energy of their *Height*, and *Weight*, to the greateſt Advantage.

Finally, if it be true, as is reported, that the *Two Coaſting Currents* of this Streight, run *counter*; that, on the *Weſt Side*, towards the *South*; while the other on the *Eaſt*, returns to the *North*; it is no more than *ordinarily* happens, when the *freſh* and *ſalt Floods* [being diverted at the *Entrance* into any of our Straits, each apart to the *contrary Side*, by ſome *ſteep Rock*, or oblique *Bank of Sand*]; the one comes *in*, and the other goes *out* at the ſame Time; paſſing by each other *distinguishably*, perhaps for a *League* together: So in our preſent Caſe, the *opposite Mouths* of the *Bosphorus*, being diverted *ſeveral ways*, direct their *Coaſting Currents*, the one towards the *Hellespine*, and the other towards the *Archipelago*, in the ſame Manner.

Thirdly, The *Atlantick Tide*, which ſets in from the *Mediterranean Sea*, thro' the Streight of *Strait of Gibraltar*, ſwells the Stream which tranſmits it thither, and lets it fall *alternately* at every *Hours End*; with an Interval of *twelve Minutes*, like the *Magellanick Gulph*; and both ſeas devolv'd together, down the *Middle* of the Channel; while each precedent Flood returns, by *Reſult*, from the *Bottom* of the *Levant*;

vant ; partly restored by *Libration*, and partly re-enforced by the *Encreasing* Pressure of the *Southing Moon*, to refund on each Side the *Coasting Current* into the Ocean, whence it came ; as the *Boat-man*, where he cannot stem the *Middle Stream*, follows the *Bank* to find calmer Water.

And, that this *Secondary Resulting Tide*, may reach the Height of the *Primary* one (besides the *Moon's* aforesaid Re-enforcement) the joint *Inclination* of the opposite *Shores*, to the *Streight's Mouth*, concurs to unite, and proportionably to raise the Height of the *Tide*, which was before dilated and lower'd on the way, from *Sicily* (the *Axe* of its *Libration*) on each Side of the occurring *Stream*, so as to refund part of their borrow'd Water into the *Ocean* itself ; 'till the undistinguishable *Union* of all three Floods in one, sufficeth to re-advance still another resulting *Tide*, to an equal Height with the former, which immediately preceded it.

Thus the *Diurnal Course* of the *Moon* drives the *Tidal Tumour* with Ups and Downs of six Hours apiece, from the Bottom of the *Streight's Mouth*, to the Point of *Gibraltar* East and West ; and the *Weight* of her Pressure being advanced, in Proportion to the Height of her Advance towards the *South* ; the *Tumour* must swell most, at the Places that extend farthest North ; as at *Venice*, in the Bottom of the *Adriatick* ; and at *Marseilles*, in the *Gulph of Lyons* ; where it swells a Foot, whereas it bears up elsewhere, scarce six Inches. But her Advance lying between *East* and *West*

the while, the yielding Tide must be driven towards *N. W.* and result from *N. E.* on the *Spanish Shores*, for Instance ; and run from *Frangerola* into the *Streight's Mouth*, at *South-west*, as is found by the *Pilot's Observation* : And, since he has furnish'd us with a very accurate *Account* of the several *Motions* of the Tide found therein, 'twill not be amiss to have their sundry *Appearances* farther examin'd, and fully discuss'd.

S E C T. VIII.

more particular Account of the Tide, in the Streight of Gibraltar, from Experience and Reason.

TO give my said *Account*, an unquestionable Assurance ; 1st, I produce for as to Matter of Fact, our *English Pilot's* Observation, in his own express Words : In regard the *Streight's Mouth* contains sundry Streams, which pass thro' it out the *Atlantick Ocean*, into the *Mediterranean Sea* ; I delineate 'em to the Eye in a Map, exactly the same with his : And, 3^{dly}, inasmuch as their Currents differ no less in Point of *Time* ; I extract their 'Periods also, out of his *Tide-Table* : only abridge, as to the general Course of the *New-Moon Tide* ; and therein, as he doth, with the Description of the *Strait*, which is peculiar to *C. Tariffe* and *Tan-ge* ; and the only one, that flows out of the

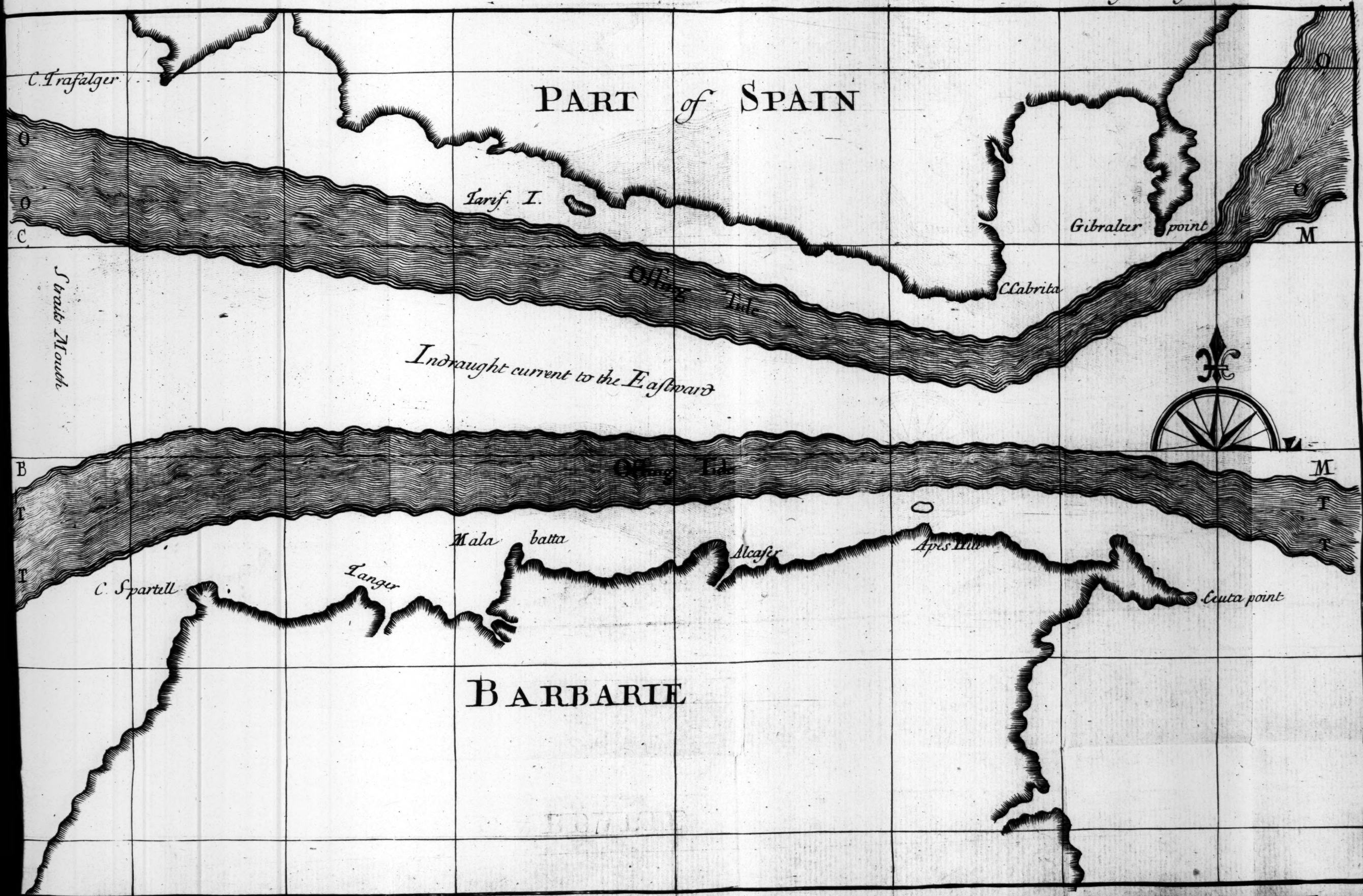
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The Pilot's Observation, of the Tide in the Streight of Gibraltar, is as follows, viz.

“ At *Tangier* and *Tariffe*, a *S. W.* by
 “ Moon maketh full Sea, at II $\frac{1}{4}$, on the *Shore*
 “ but in all Parts of the *Streight's Mouth*, the
 “ Flood runs until a *W.* by *S.* Moon, or *V.*
 “ All the other Parts of the *Streight's Mouth*
 “ have Flood out of the *West*, which runs
 “ from *C. Spartel*, and *C. Trafalgar*, on each
 “ Side, along by the *Shore*, much stronger
 “ than in the *Middle*; to the *Eastward*, as
 “ as *C. Cabrita* on the *Spanish Side*, and *Ape's*
 “ *Hill* on the *Barbary Side*; and at these *T.*
 “ Points, meets the Flood that cometh
 “ of the *N. E.* about the *Point of Gibraltar*
 “ and runs *S. W.* into the *Streight's Mouth*,
 “ the first quarter Flood; and the Remain-
 “ der of the Tide, the Flood setteth from the
 “ *Point of Gibraltar*, *W. S. W.* towards *C. Cabrita*.

“ At the *Top* of High-water, there cometh
 “ always out of the *West*, between the
 “ *Capes*, a Race of a Current, which spreadeth
 “ the *whole Streight's Mouth*, from *S.*
 “ to *Side*, but continues on neither side
 “ longer than *half an Hour*; but in the *Middle*
 “ of the *Streight's Mouth*, the Current runs
 “ the *Eastward* very strong, all the Tide
 “ Ebb; and the Race of a Current, falleth
 “ always between *Ape's-Hill*, and *C. Cabrita*
 “ at a *W.* by *S.* Moon; and at that *Instant*
 “ begins the Ebb, on the *West Side* of those
 “ Points, to run to the *Eastward*.

“ T



“ The Tide of Ebb, on the *Spanish Coast*, runs from *Cape Cabrita*, about two Leagues broad from the Shore, as far as the *Island of Tariffe*; and runs between the *Island* and the *Main*, all the Tide of Ebb, along by the *Shore*, towards *Cape Trafalgar*; but on the *South Side* of the *Island*, the Ebb runs very narrow, except it be in a Set of fair Weather.

“ The Tide of Ebb, on the *Barbary Side*, runs from *Ape's Hill* but narrow along the *Shore*, as far as the *Point of Alcasar*; but, on the *West Side* of the *Point*, thwart of the *Bay*, the Tide runs about three Miles broad; and at the *C. Malabata*, which is the Eastermost *Point* of the *Bay of Tangier*, about two Miles broad; and so continues to the *Westward*, out to *C. Spartel*; and from thence, the Ebb runs *S. W.* along the *Shore*, towards *Salley*.

“ The Ebb, to the Eastward of *C. Cabrita*, and *Ape's Hill*, is begun by the foresaid Race of Current, which spreadeth from the one Side to the other, between *Gibraltar* and *Ceuta Point*, and runs in *E. N. E.* in the *Middle*; from the *Point of Ape's Hill* to the *Point of Ceuta*, along the *Shore*, all the first half Tide; and the remaining half Tide, the Current runs from *C. Cabrita*, *E. S. E.* into the *Streight's Mouth*, by the *Point of Ceuta*; and from the *Point of Gibraltar*, the first half Ebb runs *N. E.* into them, towards *C. Frangerola*.

Thus far the *Pilot's Observation*.

The *Pilot's Delineation of the Streight's Mouth*, with regard to its five-fold Tract of *Currents*, is as I have described in the foregoing *Map*: Now, to inspect his Table of the Tides, for the *Periods* of their Floods and Ebbs, upon every Line; *First*, From the Line B, to the *African Shore*, the Tide begins to Flow *Eastward*, at 10^h; and Ebbs to the *Westward*, at 4^h: And from the Line C, on the *Spanish Coast*, it begins to Flow to the *Westward*, at 11^h; and to Ebb also to the *Westward*, at 5^h; yet, between the Offing Lines TT on the one Side, it Flows not to the *Eastward*, 'till 1^h; and Ebbs not to the *Westward*, 'till 7^h: And between the Offing Lines OO on the other Side, it begins not to Flow to the *Eastward*, 'till 2^h; nor Ebbs to the *Westward*, 'till 8^h; while the *Middle Current* still Flows to the *Eastward*, at near the same Height, without Intermiſſion.

Seeing therefore all these Floods and Ebbs, are stirr'd up, and let fall again, by the same Flux and Reflux of one single Wave, or Tumour of the Sea, yet no Two of either Sort, begin to rise or subside at the same Time; the Question is, how they become so differently dispos'd, to resent its Impulse?

First, The *Coasting Streams*, which first receive its Influence, are best dispos'd for that purpose; as having no special Inclination of their own, to resist it; nor Depth of Water, for any to be impress'd into; but, Floating upon shallow and shoaly Bottoms, are easily stirr'd, and as soon appeas'd, like shallow Lakes, upon every Wind that blows, or Calm that shall

shall happen ; and so must take the *first* Notice of any Commotion.

On the contrary, the *Middle Current*, having *Fall* enough to direct its Flux to the *Eastward*, and Channel of *ten Leagues* to continue the same ; having also *Depth* of Water to go forward, and the *Atlantick Ocean*, to keep it supply'd to its full Height : Without impediment of Coast, or Shore, to *deflect* its Course, or *lessen* it Speed, must suffer no Dependence on the *Moon*, to hinder its Precipitation.

But the *Offing Floods*, interposing between the two Extreame, must *partake* of both these Extreame, by their mutual Coherence ; the *constancy* of the one, so as to Ebb and Flow by Lunar Influence ; and withal the *Steadiness* of the other, not to be wrought upon over-hastily ; but, as it is *three Hours* later, in receiving the Tidal Impression ; so to preserve it as much *longer* ; but yet as all these different Motions being regulated, by the *side's six hourly* Revolution ; so at every six hours End, to make, by a timely Ebb, Retention. And,

First, The *Pilot* observes, that the *Coasting Stream*, on the *Spanish Side*, that begins to flow at 11^h, and shou'd continue so 'till 5^h, takes High-water at *Tariffe* an Hour and half sooner : *2dly*, That the *Coasting Tide*, near the *African Shore*, which begins to Flow at 10^h, and shou'd Ebb at 4^h, continues running 'till 8^h : *3dly*, That the *Offing Floods*, which begin not to swell 'till 1^h and 2^h, and shou'd flow 'till 7^h and 8^h ; yet fall with the general Ebb, between *C. Cabrita* and *Ape's Hill*,

at 5^h: Lastly, That the Tide from the N. E. both Flows and Ebbs to the Westward, out of the Mediterranean into the Atlantick, whose Situation must be higher, to give the Middle Current the quite contrary Motion: Now, to reconcile the Pilot's Calendar, to his Observation; and both to Truth, in the Points aforesaid;

Concerning the First Point; to wit, That the Tide which came from the N. E. and began to Flow at 11^h, and boldly enter'd the Streight's Mouth to S. W. at the dead Ebb, for the first Quarter of its Flood; ('till the Remainder was deflected from the Point of Gibraltar, to W. S. W. by the Springing Western Tide, towards C. Cabrita, and thence to Cape Tariffe); made High-water there, at 2^h 1/2; that is, two Hours and an half before 5^h. When, according to the Pilot's Tide-Table it shou'd have begun its Ebb: *Ans^w*. But the Sea was Full at half Tide there, in regard the Coasting Channel was straitest; and withal an Island was objected to its Course, when its Flux was briskest, and had Water enough to result, at its first Appulse, higher than the Stream was able to maintain, after the Energy of that Push was over; tho' it continued to Flow afterwards, to its full Time.

The same Tidal Tumour that came from the N. E. makes also Full Sea at Tangier, on the opposite Coast of Barbary, near the same Time; having pass'd from Ceuta Point, by Ape's Hill and C. Alcasar, as far as C. Malabata where the Coast most straitens, and Rocks oppose it; and withal, the Western Flood oc

cur

curs, to swell it as high at *Tangier*, as it rose before at *Isle Tariffe*; yet with this difference, that the Tide of Ebb continued its Course to the *Westward*, beyond *C. Trafalgar*; whereas this *Eastern Flood* is born to the *Eastward* whence it came, by the *Current* out of the *West*; before it reach *C. Spartel* towards the Ocean, to compleat its six Hours Ebb.

Secondly, It is observ'd, that the *Coasting Tide*, on the *African Side*, which begins to Flow at 10^h; and has but 'till 4^h, allow'd it to its Ebb by the *Tide-Table*, yet continues running to the *Eastward*, 'till 5^h at least: *Ans^w*. That the *First* of the Tide, is carried to the *Eastward* so far, by the *common Current* out of the *West*; while the *binder End* of its Flood is upon an Ebb, after the said Allowance is expired: As Sea-floods in *fresh Rivers*, Ebb near the Sea, while they Flow to the *Landward*, at a greater Distance.

Thirdly, That the *Offing Floods*, which begin not to swell 'till 1^h and 2^h, in the Afternoon; and ought to Flow 'till 7^h and 8^h, at Night; yet Fall, between *C. Cabrita* and *Ape's Hill*, at 5^h in the Evening; with the general Ebb of the *Western Flood*, in all Parts of the *Streight's Mouth*, at once: *Ans^w*. Notwithstanding, they continue their Flux to the *Eastward*, to their stated Terms of *six Hours* apiece, though they cannot re-advance the Tide to that *topping Height*, it had before; and they return not their Stream of Ebb, till it be withdrawn by the *Tidal Reflux* of the Ocean; which set it on foot so late, and was as long in *withdrawing* it Motion; which was done with equal Difficulty both ways,

and consequently must be perform'd in the same Space of Time.

Fourthly, That the aforesaid N. E. Tide, both Flows and Ebbs, along the *Spanish Shore*, perpetually to the *Westward*, quite contrary to the *Middle Current*, which runs without any Tidal Ups and Downs, as constantly to the *Eastward*; and consequently from the Higher Situation of the *Atlantick*, into the Lower of the *Mediterranean Sea*; which seems to render the contrary Motion of the Tide impossible; *Answ.* To make those opposite Flux's consistent, it sufficeth that the *Mediterranean Flood* advance above the *Atlantick Ebb*, to convert their Courses: Nor does the Flux of the *Middle Current* intermit, at Low-water, nor exceed when it is highest in the *Atlantick*, but observes the *Mean* betwixt 'em: As the *Spout* of a *Pump* keeps to a constant Stream, tho' the Water in the *Tube* rise and fall at every Stroak, ten or twelve Inches; yet the *Side Streams*, sometimes exceed the Speed of the *Middle Current*, between *C. Cabrita* and the *Congress-height*: Hence it is observ'd,

Fifthly, That the Tidal Flood out of the *West*, runs more strongly from betwixt *C. Trafalgar* and *C. Spartel*, than the *Middle Current*; which observes a *Mean* between the highest Flood, and the lowest Ebb; and follows the Shores of *Spain* and *Barbary*, 'till it meets the N. E. Flood, between *C. Cabrita* and *Ape's Hill*, where they *Counter-swell* each other, 'till the Water be full thro'out the *Streight's Mouth* (*Tariffe* and *Tangier* excepted) 'till 5^h; that the *Atlantick Flood*, which made High-water on the Promontories of *Ireland*, *France* and *Spain*,

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Spain, at 3^h; and fill'd their Ports, at 4^h; now reacheth the Bottom of the Streight's Mouth, and fills all full, at 5^h; and bears down the Eastern Ebbing, which damm'd up their Passage thitherwards, all the while: 'Till,

Lastly, As this Universal Deluge came from all Parts, and chiefly from E. or W. with a Point or two of N. or S. so, after the Top of the Tide, has broken down the Rampire of the Tumour, that withstood it; a general Push is made to the Eastward; yet, after half an Hour is over, it Ebbs every way at once, from the Topping Height: The Middle flows Eastward; the North Stream, towards Gibraltar; and the South, to Ceuta Point with Freedom, without any Deflection for the first Half-Tide of Ebb: But the Remainder is driven by the N. E. springing Flood, by degrees transversly, thwart the Mouth of the Streight, from C. Cabrita to Ceuta Point; to end this Tide, with the beginning of the next, and perfect the Circle.

The Pilot, having finish'd his most accurate Observation, gives us a Cast of his Office; by directing, how to turn thro' the Streight's Mouth, the Wind being Westerly: viz. To ply to the Windward on the Spanish Side, from the Point of Gibraltar to C. Cabrita, and from thence to Isle Tariffe: And, having Tided two or three short Boards up to the Windward, a little before High-water, and the Race of Current out of the West, the Ship is to be Anchor'd there, 'till so much of the Tide be spent, as to get over to the Barbary Side; and take the Tide of Ebb, as to fall to the Westward of the Point of Alcasar, that she may get

into the *Bay of Tangier*, by a Low-water; and observing the Tide, may turn at Pleasure.

So easily are resolv'd the *Doubts* and *Difficulties*, arising from the *various Tides* and *Currents* of those *Friths* and *Streights*, that interfere between Seas of all Sorts; particularly the *Magellanick*, the *Bosphorus*, and that of *Gibraltar*; which, for the *Multiplicity* and *Contrariety* of their Fluxes, seem to include and explicate all the rest: Only certain *Mistakes* remain to be rectified, concerning the *Causes of Whirlpools*, found in some Seas; and of *subterraneous Rivers*, fancied to be in others; and both upon *weak Grounds*, and for *impracticable Uses*, as shall be demonstrated in the ensuing *Section*.

S E C T. IX.

Of Whirlpools, *stirr'd up in the Sea*; their Dependence on the Tide; and, how they are occasion'd.

SINCE the whole Course of the Tide is *progressive*, and *direct*; as far as the Obliviousness of transverse *Coasts* and *Shores* permits: It occurs to enquire, How such a *circular Whirling* of Water can be stirr'd up, even in the *Ocean* itself, by its Means; and for what Use it may serve? And to direct our Enquiry, 'twill not be amiss to consult those *Eddies* in *Brooks*, and *Rivers*, which much resemble

in nearer home ; and examine, *how* they
be made to the Bottom ; which may be done
good cheap, and with less Labour.

First, To stir up such *Whirlpools*, as every
small Rill is capable of ; it is requisite, that
the Current which produceth it, be, in part,
deflected by some Bank of Sand, Gravel, &c.
to a shelter'd adjoining *Pool* of calmer Water ;
where it has Liberty to *wheel about* its crooked
confinement, 'till it rejoin its own Stream,
where it began to circulate : But falling with-
in its former Compass, its Revolutions still
become more and more contracted, *spirally*,
and they terminate at last, *Periwinckle-like*, in
the Center of their Circumgyration ; whither
it carries all its *Wreck* of Straw, Leaves, &c.
to turn around their own Center, without End
or Limit ; and the like happens in *Rivers*, and
Arms of the *Sea*, where the fresh or salt
Woods meet with *Shores*, or *Shelves*, which
are apt to turn and wind 'em into *Gulphs*, and
Whirlpools, of a larger Extent.

Secondly, It is to be noted, that *Sands* and
Shelves under Water, as effectually cause the
aforesaid *Deflection*, &c. as the *Banks* and
Shores do above it ; and, by the Crookedness
of their Channels, *infect* the Sea-Currents in-
to *spiral* Circumvolutions ; so that the incum-
bered Surface of the Sea-water, *wheels about*,
and is revolv'd *circularly* whence it came, in
compliance with the Streams *underneath*, by
their mutual Cohesion, as aforesaid : Thus the
Effect is patent, tho' the Cause be concealed ;
well in the *Ocean* itself, as in our *Ri-
vers*, or *Arms* of the *Sea*, according to the
several

several Situations of the *Bottoms* they move upon.

Thirdly, It is observable, that, while the Brook, or River wherein they are found continues *rising*, the *Whirlpool* flows higher about its *Circumference*, than at its *Center*; and when it *falls*, on the contrary: As other Streams are *higher*, at the Place whence they actually flow, than whither they finally tend. Hence it is, that *Flowing*, they gather the Wreck to their *Centers*; and when they *fall* disperse it: So the *Whirlpool*, for the same reason, while the Tide flows, *attracts* those Ships into its *Center*, which fall within the *Compass* of its *Spire*s; by letting 'em descend all the while, 'till they be *overfet* and swallowed up; which, upon its *Ebb* is cast up again, and scatters their Wrecks around over the Sea, by a *contrary* Revolution.

Fourthly, To make this Appearance more remarkable, it is to be noted, 1st, That *Flowing* Streams are of a *Convex* *Superficies*, so as to be protuberant in the *Middle*; and *Falling* they become *Concave*: Hence it is, that the *Flowing* Tide, makes the Surface of the Ocean to appear *rais'd*; and the *Ebbing*, to be as much *depress'd*; which makes the *Whirlpool* seem to *sink* into the Sea, at the one Season, and to *rise* out of it again at the other. 2^{dly}, Since *flowing* Streams cannot stop on a suddain, the *Whirlpool* riseth longer, than the Impulse of the Current drives it: 3^{dly}, The Channel which conveys it, being wider at its *Entrance*, than after 'tis *spirally* contracted; it must needs raise its *Center* much higher, than the *Circumference*.

Two

Two such *Gulphs*, as I have described, lie too near us to question their Existence ; the one, in our *South Channel*, near *Normandy* ; and the other is that famous one in the *Ocean*, upon the Coast of *Norway* ; both which draw Vessels *spirally* into their Cavities, by the Help of the *Flowing Tide* ; and when it *Ebbs*, return 'em back again from their Protuberances, either *broken* or *whole*, by the same vertiginous Tracts ; That, upon the Coast of *Normandy*, restores 'em to their former Liberty, *safe* and *sound* ; by gently unfolding those *Spires*, which invol'd 'em before : But that other near *Norway*, dashes 'em to pieces upon the *Rock*, in the Middle of it, and scatters their Wreck all the sea over ; without *swallowing* 'em down in *Gulphs*, or *Rivers under-ground* ; or casting 'em up again, as is commonly apprehended.

Hence plainly appears, that no Consequence can be drawn, from the alternate *Rising* and *Falling* of those *Gulphs*, that they hold Correspondence with others of the same Nature, *under-ground* ; which supplies 'em with Water, when they want it ; and takes it off again when they abound, by *subterraneous* Cavities made for that purpose : But, as a *Spout*, falling obliquely into a *Tunnel*, contracts a like *Whirling* about its Brink, whether the Pipe underneath be *stop'd*, or *open* ; so do these *Gulphs*, without any such *subterraneous* Communication, put on as *diverse* Appearances, by *swelling* or *sinking* alternately, in all places ; and rejecting vicissitudinarily, what they had attracted before.

S E C T. X.

S E C T. X.

A more particular Account of the Vortex, or Whirlpool on the Coast of Norway ; and, how it is caused in every respect.

TO exemplify what I have said already of the Nature and Production of *Whirlpools* in general, by the Recital and farther Discussion of *this*, on the Coast of Norway : In order to infer, that *subterraneous Aquæducts*, are no more required to produce 'em in the *Ocean* itself, than in *Brooks*, and *Rivers*, where no such Supplies can be pretended ; to deal impartially between them (since the Disparity must lie, in the Disproportion of the Cause, to the Effect) : First, I produce, in behalf of the Effect, the Description given of it, in the *Grammar of Geography*, which asserts ; that, in all Probability, the said *Whirlpool* is occasion'd, by some mighty *subterraneous Hiatus* : And, on the contrary, to give the Cause its due Force, and Application, I expose it to the View of *Sense*, as well as *Understanding* ; and exhibit the Place *Where*, and *How* - that Pool is seated, according to Mr. Moll's *Map of Europe* ; only enlarged, to shew what Advantage the Tide makes of the *Situation* thereof, to give the Water its *Whirling Motion* ; agreeable to the Account already given of it, in the precedent *Section* : Take here, the said

DESCRIPTION, *Viz.*

“ Upon the Coast of NORWAY, near the *Isle Hitteren*, in the Latitude of 68, is that remarkable and dangerous *Whirlpool*, commonly call'd *MAOLSTROOM*, and by Navigators the *NAVEL* of the *Sea*; which *Whirlpool* is, in all Probability, occasion'd by some mighty *subterraneous HIATUS*, and proves fatal to *Ships* that approach too nigh, provided it be in the Time of *Flood*; for then the *Sea*, upwards of *two Leagues* round, makes such a terrible *VORTEX*, that the Force and *Indraught* of the Water, together with the *Noise* and *Tumbling* of the Waves upon one another, is rather to be *admired* than *express'd*: But, as in the Time of *Flood*, the Water is *drawn in* with a mighty Force; so, during the Tide of *Ebb*, does it *throw out* the *Sea* with such a Violence, that the heaviest Bodies, then cast into it, can't sink; but are *tos'd back again* by the impetuous Stream, which rusheth out with incredible Force: And during that Time, is abundance of Fishes caught by *Fisher-men*, who watch the Opportunity; for, being *forc'd* up to the Surface of the Water, they cannot well dive again, so *violent* is the rising Current.

Seeing therefore the *alforegoing Description*, so far agreed with my former Account, that *Currents* are the *effective Cause* of *Whirlpools*, wheresoever they happen; as to acknowledge, that, in the Time of *Flood*, is made that

that terrible *Vortex*, that proves so fatal to Ships on the Coast of *Norway*: And that during the Tide of *Ebb*, the Water is *thrown out* with Violence, that was *drawn in* before; and that is said to be the *Cause*, which being put, or taken away, the *Effect* correspondently followeth, or ceaseth: The Tide stands fair to be the *Cause* of the *whirling Motion*, as well on that Coast in the *Sea*, as the Currents in *Brooks* and *Rivers*, do of their *Eddies* and *Whirlpools*, of a smaller Size.

And if it be doubted, lest the said *Cause* shou'd want sufficient *Power*, or *Application*, to produce so prodigious an *Effect*; as that, in all Probability, some mighty *subterraneous Hicatus* were required, to help it out; the Situation of the *Place*, is to be farther consider'd; and the foregoing *Map* to be inspected, to find where the Disadvantage lies: Which (if any were to be found,) wou'd be exhibited to Satisfaction.

First, As to the *Application* of the Tidal Force, on the Coast of *Norway*, where this *Whirlpool* rageth; since it setteth right upon all open Shores, from the *Middle* of the Ocean; and these of *Norway*, are extended from S. to N. and lie open to the *West*; the *Western Flood* must fall upon this Pool, at the best Advantage; as lying situated between the utmost Points of the *Isle Røst* and *Losfoet*, which bear N. and S. to each other: And, in regard the *West Coast* of the former *Island*, lies extended from Cape (a) to Point (b) from S. W. to N. E. for four Leagues together; the Declivity thereof, con-

tracting

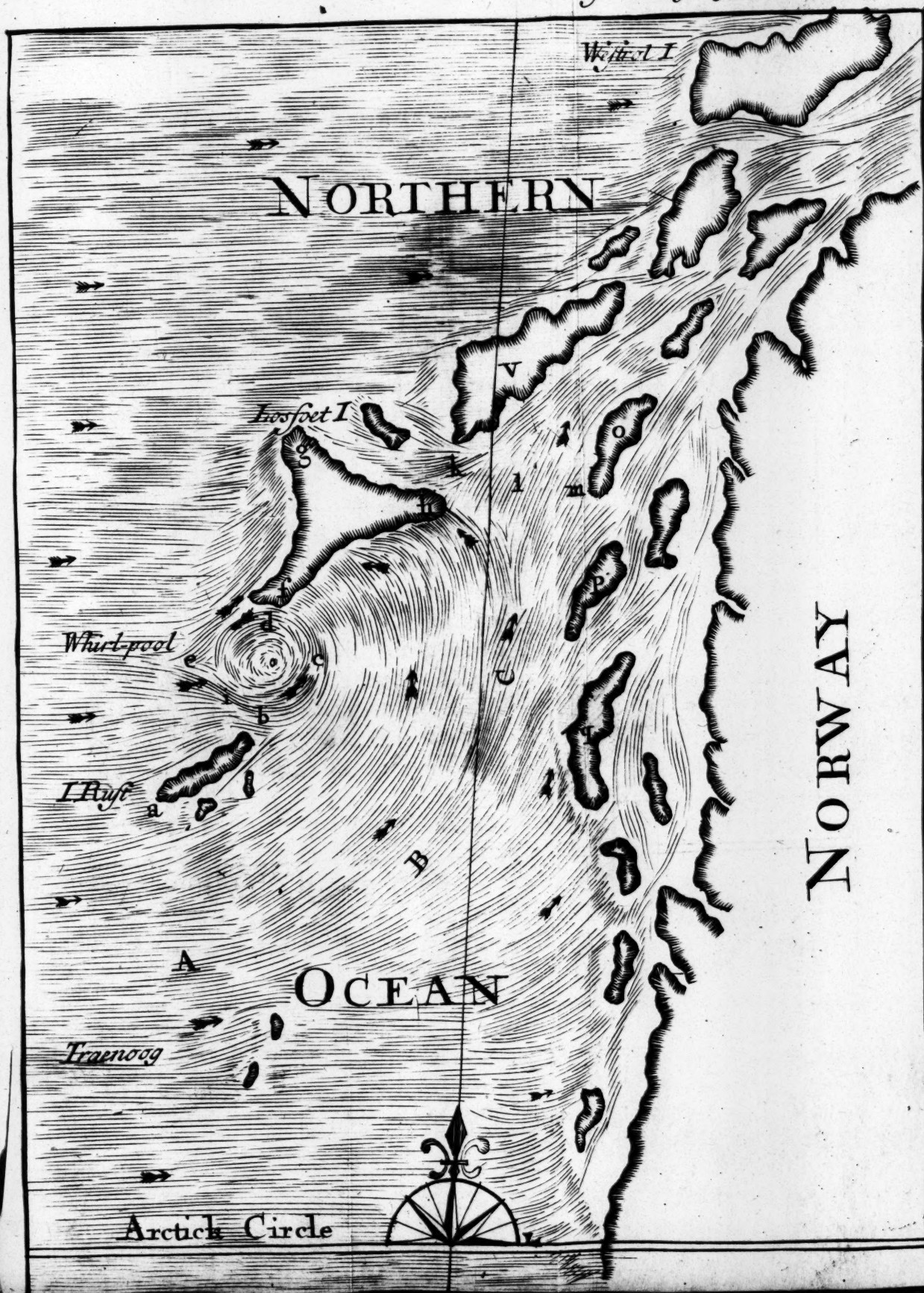
acting the Stream all that way, to a *third* part, before it touch the said Pool; it must be stronger and swifter, as *three to one*; to enforce that *whirling* Motion upon it more powerfully, than the common Stream of the *Ocean*, whence it came; and withal, its Current conquering *five Miles* in *Breadth*, must supply it with Water more abundantly.

2dly, As to the Point of *Incidence* upon the said Pool at (i), the Stream drives its Motion, on that Side, opportunely thence, from to N. as far as (c); where *this* Tidal Current, from (a) to (c), meets with *that* of (A. and C.), from the Back-side of the said *Rust*; which, with an *oblique* Stroak, directs it to full *North*: And both their Streams, being conjoin'd, are straiten'd, and swell'd up, on all Sides at once from the *Eastward*, by the *ends* (o. p. and q.); and from the *Northward*, partly by the Stream (k. l. and m.); and partly, by the S. *East* Coast of *Losfoet-Isle*; from Point (h) to (f), and their joint Stream forced thorow the Passage *between* (d.) and (e), to the S. *West*, as far as (e), into lower and calmer Water; the Tidal Stream out of the *West*, being in part carried off by Point (d), into the Bay between (f. and g), while their Stream is drawn by the other Part of it towards (i. and (b), where the *Circulation* began, and is now perfected.

3dly, This *first Circumvolution* of the Tidal Stream, about the Brink of the *Whirlpool*, being finish'd; the Flood brings on a *Second* circular Wave, which, by degrees, surrounds the former; 'till a *Third*, supervening, involves both within its Compass; into which a
Fourth,

Fourth, contracts all *Three*; as the rest do successively one another, 'till the inmost penetrates the Center of their Circumgyration, and puts a Stop to that which follows it; and each to other, as so many *Rocks*, to break the pursuing Waves; 'till the last, which flows highest, tumbles over all the rest, from upwards of *two Leagues* in Compass; with Noise and Disorder, beyond all Conceit and Expression; the *Navel-Tumour*, towards which they tend all the while, swelling to a Height extraordinary, during the Time of the Flood, which still repeats its Impulse, and furnishes Fresh-water perpetually, 'till its Flux be over.

4thly, The Flood being spent, and its Impulse lost, the Tide of *Ebb*, first withdraws the utmost encircling Wave; which lets the next Fall after it into the Deep; and the *Third*, after 'em both; and the *Fourth*, after all; and the rest successively, tumble one over another; 'till the Central Tumour (which swells all the while), be let fall over all the accumulated Ridges of Water, which supported it, from the Summit of its Height round, to the Bottom of the Ebb, with an irresistible Precipitation: So as to push away whatsoever is thrown into it, that the heaviest Bodies can scarce sink; and the Fins of Fishes can no more serve 'em here, to escape the Fishers Nets; than Rudders can steer Ships out of this Whirlpool, and save 'em from flaying in Pieces: So useless and improbable, as the *subterraneous Hiatus's*, found under the Sea, in this Section; and as vain and impossible, as the next.



S E C T. XI.

Of Indraughts of Water, and Subterraneous Rivers; and their Accommodation to Land and Sea.

THE Gulphs, and Whirlpools, mention'd in the precedent Section, are so commonly conceiv'd to be Indraughts of Water, holding an alternate Communication with Rivers, and Caverns fill'd with such Matter, under-ground; that, to go about (as I have done) to disprove it, seems to be a flat Denial, that any such subterraneous Passages and Receptacles, are probable: I shall, instead of that, labour for an Accommodation, by Relaying to what is usually urg'd in behalf of their Existence.

First, When it is objected, that such Indraughts of Water, as the aforesaid Gulphs are imagin'd to be, are required to keep Inland Seas within their Bounds, and to prevent Lakes from overflowing; and the Caspian is instanced for such; which, notwithstanding the Confluence of several vast Rivers into it, of which the Volga is one of the first Magnitude; yet swells not with its Floods; nor, in the least, presents the inequality of Rain in Winter, above the Drought of Summer:

It is reply'd, that, in regard all those Rivers drain no more Ground by their Floods, than the Caspian watereth with its Vapours; it cannot spare any Surplusage of Water, to overflow its Shores; nor needs that Sea to swell in

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Winter,

Winter, while the *Volga* is frozen up in the North ; and the Snows are not thaw'd about *Novogorod*, 'till *Mid-April* ; and are not disembogu'd, at *Astracan*, into the *Caspian*, until *Midsummer* ; tho' the rest of the Rivers most abound with Water, for all that Season : Nor is it to fall in *Summer*, upon so vast a Recruit, when those Rivers are almost dry'd up, by the scorching Beams of the Sun : So that no such Gulphs are required, to keep it up to the same Height, at either Season.

When it is alledg'd, that *Guadiana* finds a subterraneous Passage, seven Leagues long, to prevent its Inundation of a considerable Part of *Spain* ; and the *Caspian* must do the like, to pass off the Streams aforesaid, perhaps into the *Euxine*, that *Persia*, &c. may escape the said Misfortune :

It is again reply'd, that the Parity doth not hold, to make good the Consequence : For, altho' such Passages be as possible, in both Cases, as it is for *Bridges* to be made, either by Art or Nature ; and for Rivers to pass under'em, upon a competent Descent ; and such an one is necessary, in the former Case ; yet it does not appear to be either useful, or practicable in the later : For First, the *Caspian*, being of equal Extent with our *Great-Britain*, and lying as far South as *France* ; to expand those Streams, and expose 'em to the scorching Beams of the Sun ; seems sufficient to resolve 'em into Vapours, and prevent its Overflowing : Nor is it probable, that the *Euxine Sea* lies lower than the *Caspian* ; since the said Rivers run a longer Course, and require a greater Descent, than any in *Europe* : Besides, *Spain* has

less

less need of such a *Lake* ; being, on *three Sides*, surrounded by the *Sea* ; than the *Nations* bordering upon the *Caspian*, at *seven hundred Leagues* distance from it: But wonderful is the *Divine Providence*, and faithful to his Promise ; to water a considerable Part of *Africk* with the Flood of *Nile*, like a Garden ; and a no less Compass of *Asia*, by the Vapours extracted from the *Caspian Lake*, with the Dew of Heaven.

And whereas is urg'd the Necessity of such *subterraneous Currents*, out of some Seas into others, which wou'd otherwise prove superfluous, and unaccountable : *Ans.* As is mistakingly conceiv'd of the *Coasting Stream*, on the *South Side* of the *Mediterranean*, which follows the *Barbarian Shore*, from *Gibraltar*, *Eastward*, as far as *Aleppo*, without any *Return* : And of the *Current* on the *West* of the *Adriatick*, which runs perpetually *Southward*, along the *Galabrian Coast*, as far as it reaches : For these (as I have already shewn) are only *Currents*, that make *Restitution* for the *Tidal Tumours*, that follow the *opposite Channels*, which circulate into each other : But what is worth the *Remark* is, that the *subterraneous Conveyances* of Water, which are suppos'd to pass out of these Seas into any other, are absolutely impossible ; the *Adriatick*, lying on the same *Level* with the *Mediterranean*, which lies lower than the *Ocean* itself, that flows into it without *Intermission*.

Yet upon such Surmises as these, some *Authors* fancied the Earth to be an *Animal*, which rejected the Tide, and swallow'd it down again by *Respiration*, thro' bottomless *Gulphs*, and

and *Indraughts* of Water, reported to be found in *some Seas*; yet so rarely, and with so *little Effect*, even upon the adjacent Shores, that they cou'd no more be thought to influence the *common Course* of the Tide, around the Universe; than that the Flame of a *Candle* might suffice to illuminate a whole Nation: But, perhaps those Authors only pretended to *fancy* so, for an Essay of *Wit*, to try whether this Opinion (as *absurd* as it appears) was not as defensible, as any of the rest that were started, about the Cause of the Tide; to turn all their Search after it into a *Jest*.

No less vain and groundless are the Imaginations of those, who still frame to themselves such impracticable Existences, as *subterraneous Rivers, &c.* without any just Occasion; or even a Possibility to be made other Use of, than to discourage their Followers, from searching into the *true Causes*, of the Substance of the Tide; or any such Appearances of it, as these odd Fancies are pretended for; and to drive 'em into an utter *Despair* of ever arriving to any solid Satisfaction, in any such Matters: And in the mean time, they serve their *Authors* themselves, as often as they chance to fall upon any *Difficulty*, which they cannot tolerably explicate, for Subterfuges to conceal their *Ignorance*, and Starting-holes to make their Escape.

S E C T. XII.

A Recital and Explication of such Instances of the various Motions of the Tide, which seem to be the most unaccountable.

TO begin (for Method's sake) with those Tides, which immediately affect the Ocean it self ; where the Influence of the Moon's Pressure finds the least Restraint from any Interruption by *opposite Coasts and Shores* ; and thence proceed briefly in order to the rest, as behoves a Rehearſal :

The *First* Instance, which is suggested to frame this Order, is, that at *Cayen* under the Equator, the Spring-Flood makes not High-Water 'till the *fourth* Hour after the Moon's *Southing* ; nor 'till the *sixth*, after she has pass'd the Great Meridian ; and consequently, she had made an *Ebb* at their Intersection, by the Pressure of her Presence, just when it was Flood upon the *same Meridian*, within the *Temperate Zone* : *Expl.* Which is quite contrary to the common Opinon ; (*viz.* That it is Flood and Ebb in *both Places at once*) but exactly agrees with Matter of Fact, and the foregoing Doctrine.

Secondly, It is no less wonder'd at, that the Flood upon that *Island*, shou'd ordinarily rise no higher than *six Foot* ; and the Spring-Tides never exceed the rest, above *six Inches* ; especially lying so near the Congress of the *Ethioppick*, and *Atlantick* Floods, upon the Equator : *Expl.* But it is less strange, in regard

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they arrive not *thirber* at the *same Hour* ; so that that which comes *first*, carries off the Stream of the *later*, before it can mount to the Height, which is ordinary in other Places.

Thirdly, The *Ethiopick* Flood is described to come with much more Violence out of the *South*, towards the *Line*, than the *Atlantick* does from the *North*: *Expl.* And there is good Reason for it ; seeing the *former* is dilated from the *Cape of Good Hope*, to the *Magelanick Streight* ; and becomes still more contracted, by the inclining Shores of *Brasil* and *Congo*, to enforce it all the while ; whereas the *later* spreads itself to a greater Breadth, along its Passage from our *British* Coasts, 'till it reach the *Equator*, and becomes weaken'd as much, by its Expansion.

Fourthly, 'Tis observ'd, that it advanceth not to the same Pitch, at the *Tropicks*, that it doth upon the *Equator*, on the *one* Side ; or in the *temperate Zone*, on the *other* : *Expl.* Because the *Tropicks* are the *Axes* of the Tide's *Libration* ; and so it must rise and fall to its full Extent, at each End of its Reciprocation ; while the Center, whereon it moves, remains fix'd and steady.

Fifthly, 'Tis observ'd, that 'tis High-water at once, on both the *East* and *West* Sides of the *Atlantick*, in the same Latitude ; as on the Coasts of *New-England* in *America*, and of *Poitou* in *France* ; after three Hours Ebb in the Middle, and so long Absence of the Moon from the Great *Meridian* : *Expl.* Because the Tide had departed each Way, from it, towards the *East* and *West*, to the like Distance,

in equal Spaces of Time ; or else the parted Floods had been as different, both for Height and Time ; as the Tides at the *Canaries* are (which lie *nearer* to that Meridian) both stronger, and come sooner thither, than those at the *Caribees*, on the other Side of the *Atlantick* ; because they lie farther distant from its Center, which is their common Source.

Sixthly, Mariners find, more to the *Northward*, a strong Flood at *Hudson's Bay*, and a very weak one on the Coast of *Norway* : Expl. Inasmuch as the *former* opens its wide Mouth *immediately* to the Great Meridian, its common Tract ; whereas the *later* declines it no less to the *Eastward* ; and lies more remote, to the *Northward*, from the Course of the Moon, which shou'd enliven it.

Concerning the *different* Influence of her Pressure upon our *narrow Seas*, and *Lakes* ; some have no Tide at all, as the *Caspian* and *Buxine* Sea ; for want of Communication with the *Ocean* ; besides, they have neither Extent, Figure, nor Situation, proper for that Purpose ; whereas some *Lakes*, which are wholly sequester'd from all Commerce with the *Sea* (are reported to be in the *North America*, of which *Two*) having Extent and Situation proper for it, Flow and Ebb, periodically, by the Moon's sole Influence, twice in twenty-four Hours ; tho' they sometimes intermit, or else reach not their usual Height, as is aforesaid.

And as for the *Baltick* and *Mediterranean* Seas, which lie open to it ; the Tide of the

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Ocean, being almost spent in the *German Sea*, before it reacheth the *Sounding*; the former, as lying too far *North*, to be influenced by the Moon's Pressure, looseth the Tidal Effect: And the later, which lies at a more convenient Distance, partaking it with Accommodation; it most abounds where it has most Liberty to rowl towards the *North*; as at *Marseilles*, in the *Adriatick Gulph*, and the *Levant*.

Nor is it more strange, that the same Flood shou'd rise fifty Foot at *Hull*, Sixty at *Bristol*, and Seventy at *St. Malos*: In regard that at the *First Port*, our *South* and *North-British* Currents redouble their languishing Forces, by their mutual Occurrence; at the *Second*, the *Severn-Sea* gapes with so wide a Mouth, to drink in the Ocean; and swallows it down so narrow a Gullet, to raise the Tide to a Height extraordinary; and at the *Last*, the *Bay*, with a stretch'd-out Arm, takes in near a third Part of our *South Channel*, and brings it almost to a Point at *St. Michael's Sea*, to exalt it above the rest.

And in regard the River *Garrone* can contain two Floods at once, having a streight Channel, with Length, Breadth, and Depth, capable of 'em; we need not wonder, that four Tides shou'd be kept on foot at once, in the Sea, at much farther distant Places; as at the *Equator*, *Plymouth*, *Hull*, and *Amsterdam*; still pursuing one another, at twelve Hours distance, as it were from four several Stages, upon the same Road.

As for *Supernumerary Tides*, which happen oftner than twice every twenty-four Hours,

in the same Place ; they are occasion'd by a Division of the common Tide, passing into the same Gulph of the Sea, thro' distinct Channels ; and of so unequal Speed, that the one may Flow and Ebb, before the other arrives ; as sometime happens in our *Irish Sea*, thro' its *South* and *North* Channels out of the Ocean.

And in case a *Second* Gulph succeeds the first, and the Channels conducting 'em thither, subdivide the *Four* Floods already made, it happens in the *Euripus* behind the *Negroponte*, to make 'em up *Eight* ; if *One* be withdrawn within that Space of twenty-four Hours, it happens there by the Moon's Absence, only *Seven* must remain : so on the contrary, the Causes of the Tide's Multiplication being revers'd, an equal *Re-union* must follow ; so that *Four* Tides may be conjoyn'd into *Two*, and these *Two* be re-joyn'd into *One*, by acting counter to each other, (as in the Port at *Amnkin*) by their different Application.

Lastly, Whereas it is observ'd, that the course of the Tide rather adheres to the mean Motion of the Moon, than to either of the Extreams ; 'tis because the Ocean which is mov'd, consisting of a ponderous, as well as fluid Element, must still hold to its own place : like a long *Pendulum* ; which more regards the equal Poise of its own Weight, than the unequal Draught of the Clock, which keeps Swinging on foot.

And whereas the Swings of the Tide mostly continue to rise higher, for some Days, after the Change and Full ; as *January* is mostly colder than *December*, and *July* hotter than *June*,

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June, after the Sun has left his highest and lowest Stations: 'tis because, in all three Cases, the *active Power* of the Sun and Moon decreaseth less than the *passive Resistance* in the Subject Air and Water doth, to hinder the Encrease of the Effect.

So fully are resolv'd the diverse Appearances of the Tide, in all *Seas, Rivers, and Lakes*, within the Compass of our Acquaintance: and doubtless the Rest, thro'-out the Universe, so far sympathize with ours, as to be resolvable upon the same Grounds, with equal Satisfaction: And altho' the Matter thereof, being *physical*, may seem to include Obscurities; yet the Form, which is Local Motion, stirr'd up by *Trusion*, properly belongs to *Mechanical* Consideration, which admits no Doubt, when the Matter of Fact is manifest to Sense and Experience. Hence it is to be inferr'd, that the *active Power* of the Sun's and Moon's Pressure, being proper to raise it; and the *passive Dispositions* of all those *Seas, Rivers, and Lakes*, adapted to receive it's different Impressions, in the Places aforesaid; the Effect must needs follow, as to its Substance, upon their due Application. Tho' in what Measure (the Ocean, whence it first springs, being unathomable; and the Air, which conveys it, how compressible not yet known,) be left somewhat uncertain.

S E C T. XIII.

The CONCLUSION:

Wherein the Modern Doctrine of Attraction, and its Fitness to explicate the Phænomena of the Tide, is considered.

HAVING in the preceding Chapters deliver'd my own Thoughts concerning both the Causes and Effects of the *Tide*, as far as I could find them warrant'd by Observation and Experience, the best Guide of Speculation: I thought to have shut up my whole Discourse with the brief Recital and Explication of such *anomalous Motions* of it, which seem'd the most unaccountable; without engaging my self in any Controversy, or meddling at all with the different Sentiments of others.

But this grand Principle of *Attraction*, which so successfully has been made use of, by the most celebrated Philosophers of this Age, in solving some of the abstrusest and most important *Phænomena* of Nature, being apply'd to this also of the *Tide*; makes it necessary, before I put an end to this Treatise, to subjoyn some few Reflections on its Sufficiency to produce the desired Effect, as well as its Agreeableness with constant Observation and Matter of Fact.

And *First*, Whereas it is confess'd on all Hands, that the *Moon* has a much greater share in raising the Tidal Tumour, than the
Sun,

Sun, which far exceeds her in Magnitude, purely with Regard to her greater *Vicinity* to the Sea: To argue consequently upon the same Grounds of *Attraction*, it must be concluded, that our *Terrestrial Globe*, thro' the great Advantage of its Bulk, (its Mass of Matter being to her's, nearly as 26 to 1) and its close Approximation to the Ocean, must, by a just Computation, be much more enabled to *restrain* the said Tumour, than the Moon's Attraction can possibly be to raise it.

2dly, To make *two* Floods diametrically opposite to each other with one diurnal Revolution: we have shewed; how the *Rising Moon* gradually depresseth the Sea into an Ebb, between the *Tropic's*, 'till her Southing: The Water so depress'd correspondently advancing all the while *two* Floods, collaterally beyond 'em, upon the *same Meridian*: Each of which, by falling, in the next six Hours, into an Ebb, fetcheth itself up, by *Libration*, upon the *Equator*, to the *same Height*, at her Setting. And six Hours after, returns at Midnight, by *Counter-libration*, to the *same Point* whence it first came; to counterpose, at 12 Hours end of the Flood, which is rais'd by her Pressure with the *Antipodes*; both hap'ning, in diametrically opposite Points, at the *same Instant*. And the like *Contraposition* must be concluded of all the Floods and Ebbs within or without the *Tropics* respectively. But now to make High Water in both Places at once, by one single Draught of *Attraction*; maugre its Reluctance and the Water's *Centripetal* Tendence, joyntly hindring its being rais'd on the contrary Side.

side ; and this without calling in the Assistance of Tidal *Libration* and *Restitution*, to continue a *Counter-motion* in all Places, and at all Times respectively, seems to me inconceivable.

3dly, Besides the Consonancy of this Succession of Ebb and Flood (by *Libration* and *Counter-libration*) to the Laws of *Statics* ; it gives, moreover, but little or no Disturbance to the *Sea* or *Navigation* : For, in regard the Rise of the Tide above the Ocean's common level, near the *Equator*, scarce exceeds six Foot, as has already been observ'd ; and its Ebb's *Depression* sinks only so much below it ; and their Rise and Fall beyond the *Tropics*, can be no more than answerable thereto : And again, the Motion of the interposing Sea, to supply the Extremes, is still proportionate : Hence, no part of it needs move faster than about 6 Foot from its Fellow in 6 Hours space ; the whole Body of the Ocean's Water moving together at the same slow rate : A little Disturbance doth the Tide give to the *Sea* itself, or Impediment to *Navigation*, in either respect ; whereas *Attraction*, by drawing the Surface of the *Sea* toward the *Equator*, and letting it fall back again toward the *Poles*, reciprocally ; causeth such a progressive Determination in it, as must needs drive the *Ship* quite out of her Road, at so vast Rate, as to render the Art of *Navigation* impracticable. Add to this, that the Figure of the *Earth* being suppos'd that of an *oblate spheroid*, and its Diameter toward the *Poles* shorter than toward the *Equator* ; the Water of the *Ocean*, rais'd by the *Moon's Attraction* be-

between the *Tropics*, wou'd descend by its own Weight, after the Force of that Attraction was over, with a Degree of Acceleration proportionate to its Access toward either Pole, which must occasion yet farther Inconvenience to the Sailor.

4thly, The Moon's Course holding perpetually between the *Tropics*, or near unto 'em; the Force of her *Attraction* shou'd draw the Flux of Tide constantly that Way; and withall, she passing successively from one Meridian to another, it shou'd respectively attend her thither: Besides, the Lines of her *Attraction*, the shorter and more perpendicular they grow, their Operations shou'd become the more powerful; and the farther the Flood follows its Draught, the higher it shou'd be advanc'd; whence it must needs follow,

1st, That the proper Tendence of the Tide shou'd drive it from *East* to *West*, and the Waves be still more accumulated to the *Westward*; whereas Experience tells us, that the Mariner suffers not the least Drift of his Ship that way, save by the *Trade-Wind*, which floats on the Surface of the Water; whilst the Tide dives into the Deep, and keeps its Seges in the Ocean, under Water, *North* and *South*, without the least Impediment to his Voyage.

2dly, That High-water should always attend the Moon's Motion, from *East* to *West* around the Globe; and that it shou'd be a Flood every where, when she is actually present upon the Meridian of the Place: Whereas, it has been made appear, by divers Instances, in the foregoing Treatise, that it is constant

antly both High and Low-water at once under the same Meridian, tho' in far distant *climates*; that is to say, Low-water between the *Tropics* and the *Equator*, while the Moon is actually present there, to stoop it by her pressure; when it is High-water between the *Tropics* and the *Polar Circles*, under the same Meridian, by way of *Result*, at a farther Distance from her.

3dly, It must also follow hence, that it would flow higher at the *Tropic of Cancer*, being more South, than at the *Streights of Gibraltar*; and at the *Caribees*, which lie most *S. West*, than in any other Part of our *North Atlantic*; quite contrary to all Observation.

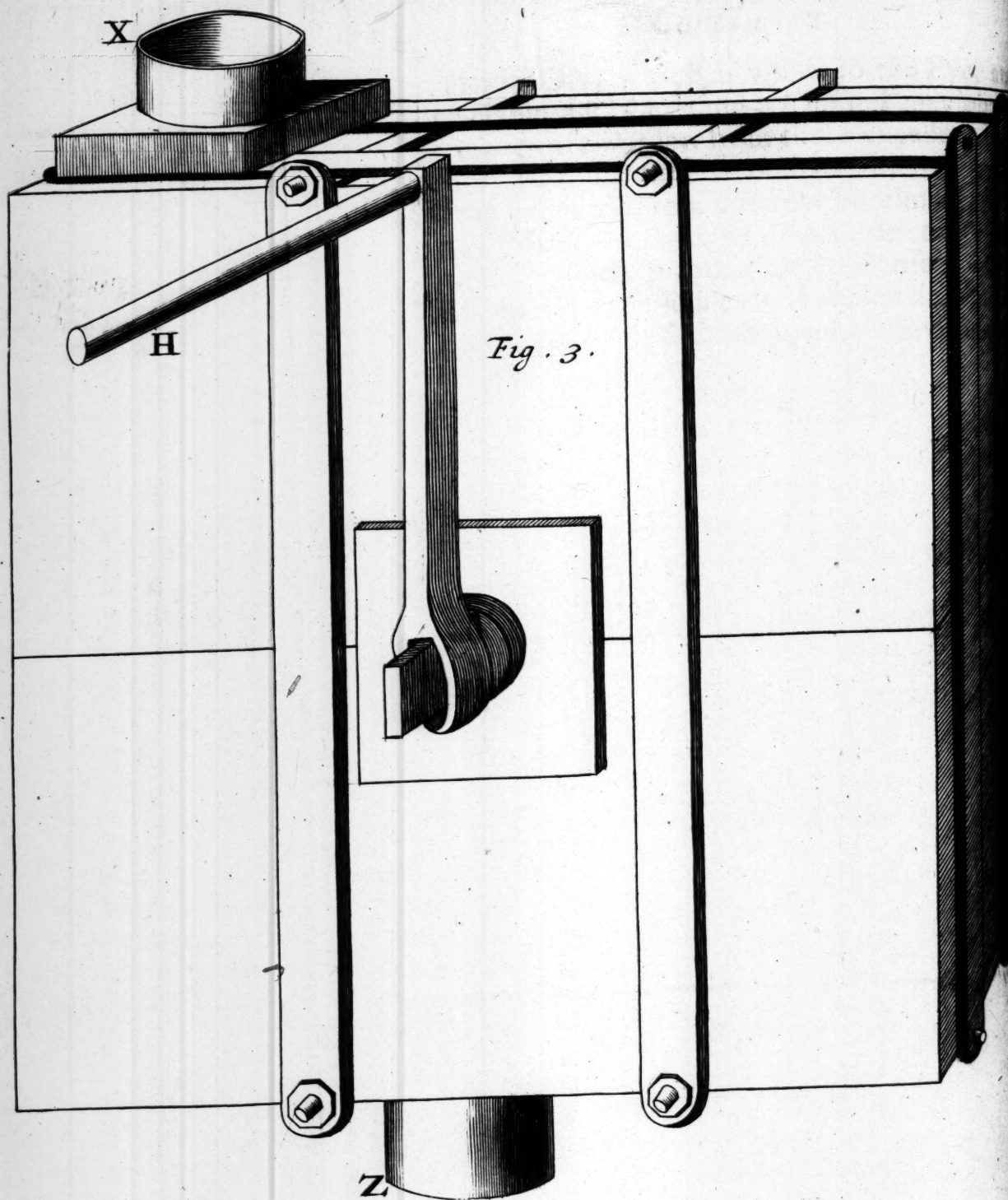
At least, highest Water shou'd constantly happen where the first Meridian intersects the Equator, when the Moon is actually near the same Point, to give her attractive Power the best Application: The Subject Ocean, being equally dispos'd to receive the Effect, by the greatest Liberty of Sea-room possible to produce it: Yet on the contrary, there, and there is found the lowest Ebb: as has been proved from the best Accounts of Navigators, and their *Tide-Tables*.

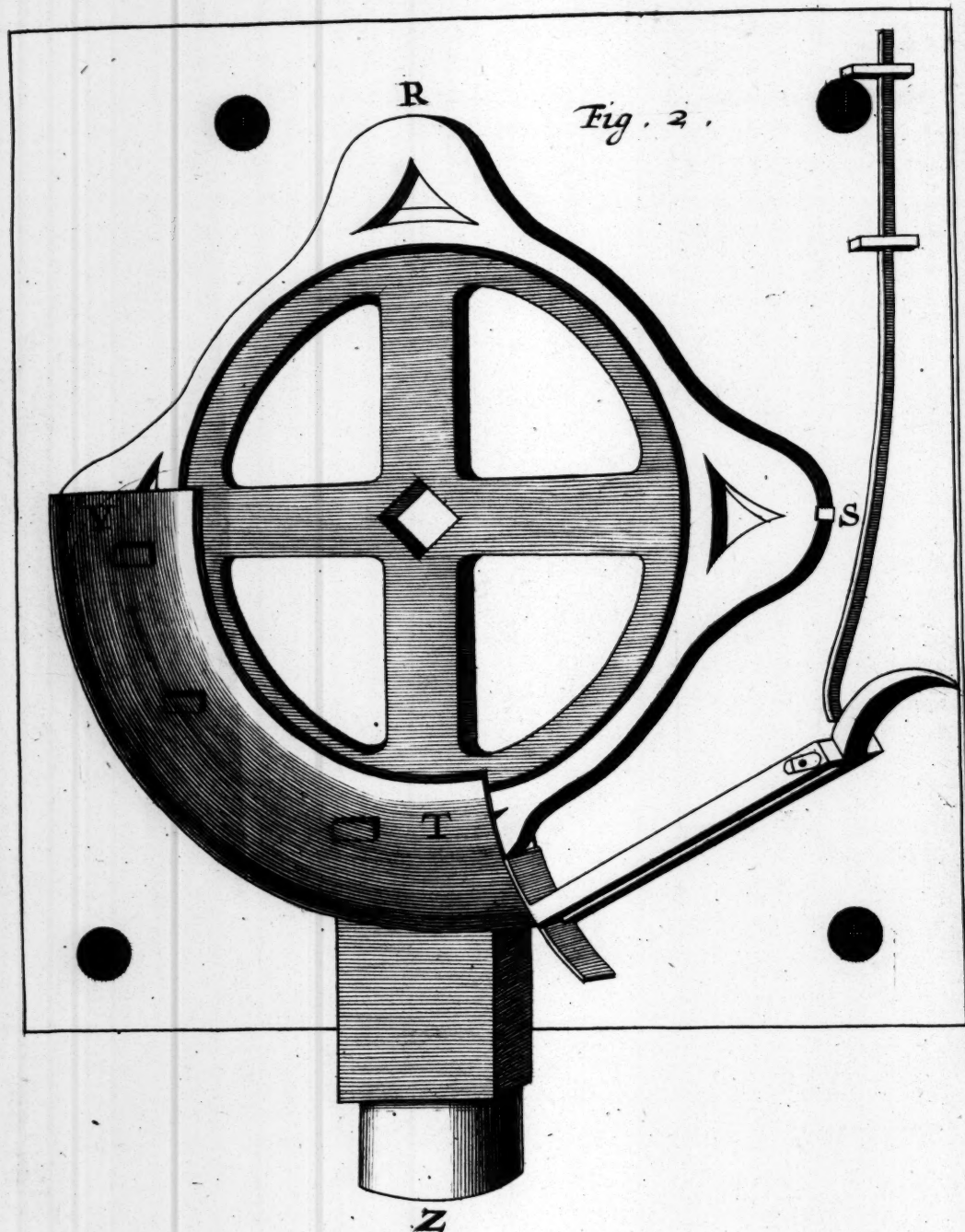
Lastly, Altho' it cannot be denied, that the great Tumour may be caused by *Allevation* as well as *Depression*, as has been already noted: But, in regard, *Attraction* is no other than an *elastic Quality*, whose Operation being unexampled from any of the known Laws of Motion, (especially by such who maintain the necessity of *Vacuties*) is to be resolv'd entirely into the Omnipotent Will of God; and therefore much less accountable for than

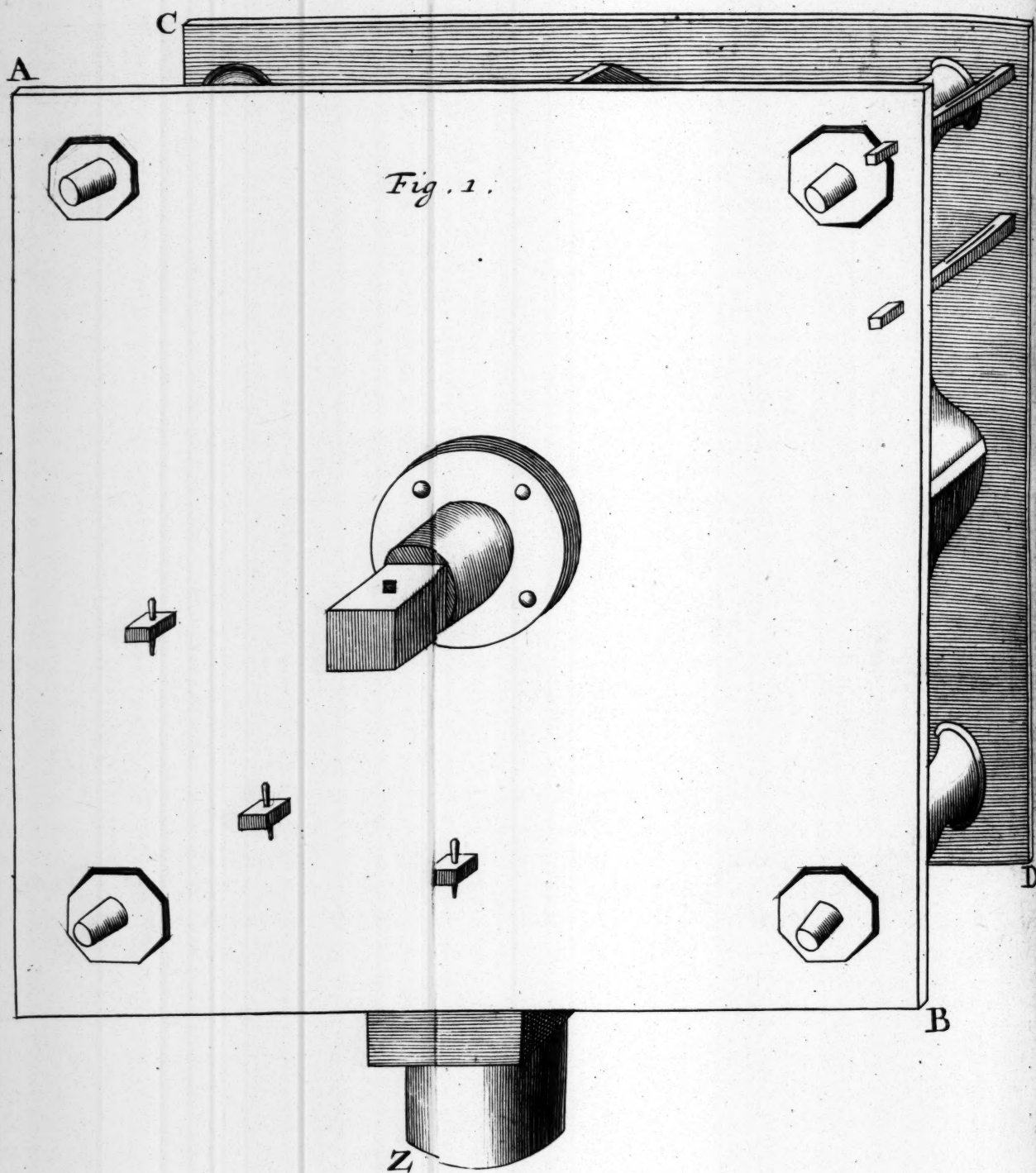
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TRUSION, which is visible to the Eye, and tractable by the Hand : I hope I may obtain a more easy Pardon from those excellent Persons, who in the Earnest Pursuit of Truth have been led into a different Sentiment; if in this Matter I have had Recourse to *Pressure* alone : which is manifest to Sense; whose Effects are undeniable; and which answers all the *Phænomena* of the Subject I have endeavour'd to explicate.

FINIS.









A Clear and Succinct

DESCRIPTION OF AN ENGINE

Which fetcheth

WATER out of the Deep,

AND

RAISETH it to the Height design'd,
Progressively, by the same Motion.

CHAP. I.

TO render the proposed Description more intelligible; for Method and Clearness, the whole Discourse is divided into Three Chapters, or Sections: The *First* whereof, declares the several Perfections and Advantages of this Engine:

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The *Second* discloseth the Defects, and Impediments of others: The *Third*, shews how the Perfections of the former, correct and supply the Defects of the Latter: And each of these is subdivided into Four or more Sections, or Paragraphs, as the Matter shall require.

S E C T. I.

Of the plain Construction of the Engine; the Use of its several Parts; and their Proportion to the Quantity of Water, which is to be rais'd.

THE Frame (*Fig. 1.*) which sustains the Work, consisting of two Plates, (*A, B, C, D,*) rais'd upon four Pillars, like a Plate-clock, contains within 'em a Central-wheel; whose Rotation, by the Help of four Ladles, (*Fig. 2, R, S, T, V*) passing successively thro' a Channel *V, T*, for a Quadrant of its Circle, from the Perpendicular to the Level of its Axis, both sucks and protrudes the Water Progressively, out of the lower *Z* into the higher Tube *X*, affix'd respectively, by two Muzzels, to the Outside of the said Frame; which also contains a Clough, that, being open'd by the Forcers, at their Entrance into the Channel, is shut again after 'em, by a Spring, to hinder their Stream from returning, which are all the Integral Parts, belonging to the Engine; and these are the Uses they are put to.

Now, concerning the Size of the Parts of the said Engine, in Proportion to the Quantity of the Water, which is design'd to be rais'd: The *First* Consideration, which leads to all the rest,

is, to find by Experience, a Tube of what Bore, will carry off the design'd Stream at a competent Rate, to give Satisfaction; and if one, for Example, of four Inches diameter, will serve the Turn. *Secondly*, The Channel is to be wide and deep enough, to supply it; and being expediently wider than deep, near five Inches hollow will be required: And *Thirdly*, Ladles must be of the same unequal Breadth and Depth, to fill it so exactly, as, in some measure, to hold Water; and allowing for the Sides of the Channel, one Inch more. *Fourthly*, The Pillars which raise the Plates, to contain the whole Thickness, must be six Inches at least: So that if the Tube be four Inches, the Channel must be five, and the Frame six Inches wide; as is manifest.

Lastly, Altho' the Ring of the Wheel must necessarily be as broad as the Ladles fix'd upon it to sustain 'em, and fill the Orifice of the Channel so closed, as to let no Water leak out; and withal of so large a Compass, as to allow a proportionate Distance betwixt its four Ladles, to hold a Competency of Water; yet it is to be enlarged upon Occasion (and consequently the Plates of the Frame also) to whatever compass, the Force and Speed of the first Motion shall require: And still the stronger and slower this is, the Wheel must be larger in Proportion, to keep an equal Pace to the design'd Performance, in all Cases: Such is the Proportion of every Part of the *Engine*, to the Quantity of Water, in all respects: And So exactly is the whole Series of the parts of this *Engine*, adapted each to other; and the Size of 'em all is so proportion'd, to the Quantity

Quantity of the Stream they are to manage; and comparatively thereto, so small and minute, and withal so close compacted together; that the whole Frame of 'em needs not to exceed two or three Foot in Height, and as much in Breadth; and eight or ten Inches in Thickness, to supply any Use; yet the larger the Engine is, the Performance still proves more effectual, with Regard to the Force apply'd; whether the Quantity of the Water, or the Height whereto it is advanc'd, be consider'd. Now its Organical Parts being all so well prepar'd for Action, let us proceed to shew the Efficacy of its Operation.

S E C T. II.

Concerning the Ease, and Efficacy of its Operation.

FIRST, Since all Motion is suppos'd to begin from Rest, and to encrease by Degrees, till it arrive to some determinate Speed; hence, Water is rais'd by the said Engine with the greatest Ease, gradually, from its horizontal Position, up the Quadrant of a Circle, till its vertical Motion becomes Perpendicular; and having attain'd to its utmost Speed successively, the forcer that rais'd it leaves it.

Secondly, As a single Force is the best; the forcer which raiseth it (for Example, the Hand of the Artificer) lays fast hold on *H*, the Handle of the Turn, which is immediately join'd to it, and moves together with it; without the Interposition of any Obstacle,

to hinder or weaken their joint Motion; and consequently they perform their Lift, to the best Advantage.

Thirdly, The Motion of the Water upward, being render'd Perpendicular, by the Curvity of its Channel *V, T*, still inclining it that Way, its Stream passeth freely into the upward Tube *X*, (*Fig. 3.*) which is plac'd just over it, and is of the same vertical Tendence; and is carry'd upwards ever after, according to this its first Direction; the better to preserve the projectile Impulse, already impress'd into it.

And not to suffer its upright Motion to cease, or intermit, another Ladle of Water is immediately thrust up into it after the former, by the succeeding Forcer; and so one after another, quarterly; four of 'em *R, S, T, V*, being affixt around the Ring of the Wheel (which shuts up the upper Side of the Channel) at equal Distances; to come all in play successively at every Revolution, and render their Performance perpetual.

Fourthly, As the said Forcers, passing successively thro' the Channel, push up each its Portion of Water into the upper Tube, to be carry'd off at the Height design'd: So respectively, by the same single Motion, each sucks up a proportionate Stream from the other Tube *Z*, fixt at the lower End thereof; the Ponderation of the Atmosphere, forcing up (by its Pressure upon the Superficies of a Pond, or River underneath) a competent Portion of Water, to supply the Evacuation: Thus each Forcer at once, pusheth one Portion of Water before it, and sucks another Draught after it, to make the Supply, as well as the Evacuation, successive

cessive to a Perpetuity ; with all the Speed, and Expedition imaginable. Now

Fifthly, To hinder the Motion of Water from circulating (together with the Forcers which drive it) thro' the Body of the Engine, out of the upper End of the Channel, back again into the lower, to perfect the Circle.

First, On the trusive Part ; when the Stream, which is thrust up the Channel, has fill'd the Body of the Engine, it can follow the Motion of its Forcer, no longer that Way ; where all is full to obstruct its Passage, and so is compell'd to ascend into the higher Tube, X, where it finds vent upwards, according to its present Direction ; and mounts more freely, by the Energy of its former Impulse, and with most Ease thro' Water, as being of the same fluid Constitution. Nor

Secondly, Can the said Repletion be evacuated downwards, on the Suction Part, into the lower End of the Channel ; its Orifice being shut up so close by a Claugh, after the Forcer's Entrance into it, that Water cannot follow it that Way ; and consequently, the Ladles pressing forwards into the Channel, must needs leave a Vacuity therein behind it, to be supply'd from below with Water, by the Pressure of the Atmosphere, as aforesaid, to keep the Suction on Foot, as well as the Protrusion, that the Operation, on both Parts at once, may be render'd compleat.

S E C T. III.

Of the great Force, and large Extent of this progressive Engine's Performance.

TO calculate the utmost Reach of its Performance, both in Respect of Force, and Extent; First, from the Quantity of the Water which it is capable to contain; Secondly, from the Height it is able to advance its Stream, with Regard to the Force employ'd to raise it, and the Space of Time, wherein the Work is to be accomplish'd; it is to be consider'd,

First, As to the *Quantity* of the *Stream*; a greater may be rais'd, progressively, by this Sort of Engine, with Regard to the Smallness of its Size, than can be expected from any other; as requiring to be no thicker, than to contain a Tube of as large a Bore, as will suffice to convey the Current with a free Passage; nor of a greater Compass, than to include a Wheel of a competent Circumference, to admit of four Ladles at a proportionate Distance from each other, to hold Water enough, as corresponding to their Height, and Breadth, while it is turn'd by a weak, and quick Hand: But in Case the Motion be strong, and slow, as is a Water-Wheel; this of the Engine may be enlarg'd, to keep Pace with it, without any Alteration in other Respects.

Secondly, Concerning the *Height*, to which the Effect of this Engine extends; since it

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Description of an Engine,

may fall short of its Pitch, either, First, by the Loss of too much Water, from the Pressure of that Height; or, Secondly, the Force of the Mover may be as much weaken'd by Friction; these two Rubbs are to be remov'd out of the Way.

First, As to Loss of Water, from Pressure at any Height; since the Bulk of it is encreas'd according to all its three Dimensions, at once; much more proportionably to its Surface, than can possibly be squeez'd out of its Substance; especially, in Regard the Work in a large Engine, may be as close jointed as in a small one: Hence, this Sort of Engine must needs be the least Sufferer, of all other in that Kind; which is capable of Enlargement, without Limit, and may contain any Quantity of Water, whatsoever.

Besides, since the upper and lower Tubes, are suppos'd to be affixt to the Box which includes the Engine, so closely as to hold Water all along from the Top to the Bottom; and not one Drop can issue out of the Channel into it, which is fill'd already and the higher the Water is rais'd in the upper Tube, the greater is the Box's Reluctance to receive more: Hence all that is spilt, must fall back again down the Channel into the lower Tube, which cannot be considerable, tho' the Pressure be never so much advanc'd; being shut up, both at the End, Bottom and Sides, by the Clough and Forcers, as close as is possible.

Thirdly, provided the Force, which is design'd to lift any Quantity of Water, be proportion'd to its Weight; no farther Regard is to be had to any incidental Friction of the Forcers

Forcers upon the Sides and Bottom of the Channel, or occasional Reluctance of the Claugh, to open and shut; their Contrivance being such, that no Weight of Water whatsoever, can harden the former upon 'em, or deflect the latter in the least either Way; nor add to their Friction in any other Respect, than what properly belongs to their Axis, which is always allow'd, and scarce accountable.

Lastly, To assign a competent Space of *Time* for the whole Performance; Suction being the first Step towards it, and Trusion the last; Nature itself (the Air being evacuated) makes the former *Gratis*; the Weight of the Atmosphere buoying up the Stream in the lower Tubes usually, four or five Yards, on its own Accord; while Art accomplisheth the latter, by applying the Power of the first Mover to the Forcers themselves; so speedily and effectually, as to lose neither Time nor Labour: One Gulp of Water, pushing successively another upwards before it, with the same Vigour and Celerity, no retarding Obstacle being permitted to interpose.

And forasmuch as to force any Quantity of Water to a determinate Height, with an equivalent Power, and a proportionate Space of Time, by pure lifting, without any sensible Impediment of Friction, &c. besides the Weight of that dull Element, is all that Nature will allow, or Art can contrive; it remains only to be try'd, how this Theory will come off in Practice, with a commodious and serviceable Application.

S E C T. IV.

Of its suitable and commodious Applicability, to all Kinds of Uses.

THat this Progressive Sort of Engine may be more commodiously to all Uses, on every Occasion; it may be turn'd indifferently, either by Wind, or Water; Horses, or Mens Hands; and by these either jointly, that is, by two, three, or all four ways at once; or by each severally and apart, in different Circumstances.

First, To fetch up its Stream out of the deepest Mines, by the Help of Gynn-Work placed above-ground; either Wind, Water, or Horses are serviceable enough: But Wind join'd with Horses, (forasmuch as both move horizontally) suit best together; the former, to force; and the latter, to regulate their joint Motion; the Wind, by heightning it at every Blast; and Horses, by abating it again to a constant rate; and holding out better (by the Easement of those repeated Blasts) for whole Days at once, than to be kept to the utmost Stretch of their Draught (as is usual) for two Hours Space together.

Secondly, It serves as well for draining Fenna, and marshy Grounds; and is turn'd either horizontally, or vertically, by the Impulse of the Wind; and being capable to be enlarg'd at Will, in Proportion to the Sails that drive it, 'twill discharge any Quantity of Water whatsoever; and the greater it is, still the better indefinitely, if all things else be proportionate.

Thirdly,

to fetch Water out of the Deep.

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Thirdly, It is no less accommodated to Ships of any Burden; its Bulk being small, and its parts compact, to be easily manag'd; and with its Figure, cubical, to be fix'd wherever it is placed; and may be ply'd by many Hands at once, to do the Work of as many Pumps, with one single Motion; and may be play'd either above Decks, where Suction alone will suffice, as in Merchant-Ships; or else in Men of War below 'em, by the Help of Protrusion added thereto, to keep both itself and its Managers out of Gun-shot; and if the Top of its Tube chance to be knock'd off above Water, it may be as easily supply'd by another, as a Candle may be set in a Candlestick.

Fourthly, It is able to supply Towns, Castles, &c. of the loftiest Situation, at one Lift; and to furnish 'em with a competent Stream, by one and the same single Motion; encreasing its Force, and exhibiting its Capacity, at once, by all the Manners and Means above-mention'd: but to the greatest Advantage, and with the most effectual Application, when it is turn'd by a Water-Wheel, so proportion'd to its own, that both may move concentrically together at the same rate; their Axes being so conjoin'd by square Hoops, that each may carry the other along with it, without any interposing impediments; which, being all remov'd, leave no Possibility for Art or Industry to improve the Operation, or heighten the Performance.

Lastly, One, and the same individual Engine may, on Occasion, be convey'd from Place to Place, to supply those several Offices successively, and be fitted and refitted for Service, in

Description of an Engine,

in a few Hours Space: And, whereas others seldom exceed five Tuns *per* Hour, to twenty Yards; this may raise fifty Tuns in the same space of Time, full fifty Fathoms; yet neither for Bulk, nor Weight, exceed a Waggon-Load.

Such are the distinguishing Perfections and Advantages of Operation, Performance, and Application, which this Progressive Machine performs above the rest, that none can reach it in any respect: But to make 'em more remarkable, by the contrary Defects which they sustain, and the Impediments wherewith they are pester'd, and render'd less effectual; they come now to be recounted, and deliver'd in their natural Order, in the next Chapter.



C H A P. II.

Of the Impediments, and Defects of all Water-Engines, the Progressive Sort excepted.



Since all the Disadvantages of other Engines are manifestly occasion'd by their several Deviations from the aforesaid Progressive Tract, which is the shortest, readiest, and of best Performance possible: They are (for Brevity and Clearness) to be recounted as such; by shewing at every Step, how they deflect from it; and what Accident occasion'd it, in a kind of natural Order.

S E C T. I.

First, In regard we find Buckets to be of greater Antiquity, for drawing Water out of Mountains, than Pumps; and to be of more Simplicity, and less Art: We begin with the Consideration of Gynns, and Whimseys that make use of 'em; and it is to be remark'd for their Advantage, that they spend too much Time in Filling and Emptying, to be expeditious: Whereas the said Progressive Engine is always full, and overflows, so as to lose no Time on either Account. *Again*, If their Lift be taken from a great Depth, much of their Load

Load is lost in the Carriage; but in the Progressive Way, if the Tube prove staunch, not one Drop is spilt from the Bottom to the Top; after all, their alternate Returns are unmanageable, either by Wind, or Water; whereas this Sort complies with both, either together or apart.

Secondly, The Churn-Pump, which is the plainest, and most commonly used, altho' it both sucks and lifts its whole Stream, from Bottom to Top (as the Progressive does) at every Stroke; yet withal it intermits half the Time in both Respects, while its Sucker stoops to fetch up a new Supply, for which the Progressive Forcers have no Occasion.

And the Chain-Pump, in a farther Account with our *Engine*, at one Draught both sucks and lifts its whole Burden, with a continual Progression; but withal is so choak'd up with its Saucers, and overloaded with its Chain, both which so rake the Inside of the Tube, from the one End to the other, that 'tis but of a scanty and heavy Performance: Whereas in ours, one Ladle of Water incessantly forceth up another without Intermission.

Thirdly, Concerning Trusive-Pumps, which drive the Water downwards, to fetch it up again by Rebound; they are disadvantageously made use of by *Water-Engines*, as being design'd for raising its Flux, from some lower Situation of Ground, up to a higher: For, by this Means half of their Labour is lost, as well as the Time; the greatest Part of their Force, being discharg'd against the Bottoms of their Troughs, and the briskest Part of their Pulses being broken by their Repulse from 'em, before

Result of the Stream, can be considerably re-advanced.

Nay, the Pulses of those Protusive Pumps being perpendicular, and the Motion of the impell'd Streams suck'd into their Cylinders, and push'd out again, Horizontal; much of the impress Power is lost, both those Ways: As an Arrow, by every Glance, loseth both its Strength and Speed; and a Cannon-Ball, after the first Graze upon the Surface of Water, can do the adverse Ship little Harm: So the Forcer, being depress'd by a curv'd Line, must stagger all the while, and give but a stumbling Stroke after all: Whereas in the Progressive Way, the Forcers, how crooked soever the Channel be, which conveys the Water out of the lower Tube into the higher, (their Motion being circular) still pursue their Streams at rights, thro' the same Path; without the least Diminution of their Pulses, to render 'em less effectual.

Fourthly, Forasmuch as every Ounce of Weight, added to the Forcer, requires an Overplus of Strength, to fetch it as speedily up again: Hence it is a great Mistake, to beat down the Water with pondrous Malls, to make a correspondent Result; and meely serves to redouble the Forcer's Misapplication, to brandish each Log of Wood in the Air, instead of affecting the Water more effectually: A Method much different from our Progressive Conduct, whose Engine-Wheel is light, and equiponderous on all Sides, and every Ladle hath its Opposite for a Counterpoise.

Fifthly, When those solid Hammers are exchanged for hollow Cylinders of Metal, to slide gently up and down at every Stroke, the one

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within the other; if the Motion be single, it loseth, as abovesaid, half its Time and Labour; and in case it be double that the Forcer, at the one End of their Libration, may push, while the other withdraws reciprocally: However, in the Interval of their exchange of Offices, their common Stream is left at a stop, for a redoubled Force to restore its former Speed; which gives a sudden Jerk to the Tube, which must be fortified to sustain it: A Counter-buff, not incident to our Progressive Conduct.

And, if the said Pumps be multiply'd, and the Stream be divided respectively, to render their common Current perpetual, and constant, by a regular Confluence of their Rills, to replenish it; yet withal, by intermitting as successively, to operate one after another, they become a more constant, and lasting Impediment; every one of those Rills, how small and minute soever; holding the first Force in suspense, in reference to its one Part, while it expects a new Supply of Stream, after every Stroke: Besides, the great Difficulty to drive 'em singly each thro' its slender Pipe, their Friction and Adhesion to its Sides, being encreas'd in Proportion to their Surface, from their manifold Division; which the Progressive Turn never requires, being capable to hold any Quantity of Stream, and to manage it without Intermission.

Finally, To have Recourse to Plurality of Lifts, in any Case, is a false Step; since one single Progressive Engine wou'd, at once, mount the largest Stream, to the greatest Height, with least Labour: Again, to prepare a new Engine for every Lift, would (besides the Pains and Charges)

Charges) have the Energy of the first Impulse, to renew at every Turn; and to stretch it beyond its stinted Pitch, were to accumulate all the aforesaid Incumbrances, till they became insuperable: And to be acquitted from 'em on any other Account, wou'd be a Task impracticable; since the best of every Sort, have been ever obnoxious to all, or most of those Rubbs, as will plainly appear by the following Instances.

S E C T. II.

How obnoxious the best Water-Engines, of other Sorts, are to the above-mention'd Impediments; shewn by Examples.

TO Instance those Two *Water-Engines*, which chiefly furnish the Capital Cities of our Nation, *York* and *London*; which were doubtless accounted the best extant for that Purpose, when they were made; and that stupendious one, at *Marley*, which the World so much admires.

It is remarkable, that all Three stumble, at the first Step, upon Trusive-Pumps; which, like Boar-Men, look one Way, and Row the other; and spend the Briskness of their Strokes against the Bottoms of their Troughs, before their Streams (which are beaten downwards at rights) can make their Returns upwards again, by Result; which, being but a Secondary Motion, must be both retarded and enfeebled by the Repulse.

Description of an Engine,

First, As to that at *Tork*; beside the Awkwardness of its Strokes, to brandish Three Loggs of Wood, of 1000 Pound Weight a-piece; as their Weight little avails to sharpen their Force (the Crank they hang at, having a Counter-Poise of equal Weight on the other Arm, to hinder it;) yet their Equilibriety lessens not their Weight, nor awakes their sluggish Reluctance, to be tofs'd up and down at once, by the same Motion; which is retarded at all Times, both Ways alike.

And, whereas that Machine under *London-Bridge* (beside the Weight of Water which they engage to raise) has Sixteen Pumps, to be hoisted up and down at the same rate, by every Revolution; so much to the Disadvantage of its Performance, that, as the one, without those Pumps, wou'd raise more Stream with one Water-Wheel, than it does at present with two; so the other, without those Loggs of Wood, would do more with two Horses, than it does now with seven.

And what additional Pains a *Water-Engine* must take, to advance its Task to so great a Height, as to require more Lifts than one; and how it is to be accouter'd for that Purpose, will best appear by

A Description of the Water-Engine, at Marley, in France, viz.

" It is a Machine, that, by the Force of
 " Fourteen Water-Wheels, of Thirty Foot
 " Diameter, forceth Water 450 Foot high at
 " three Lifts, by Way of Protrusion; the Tubes
 " not rising perpendicularly, but lying along
 " the

the Side of a Hill, at least half a Mile in Length: The Pumps are mov'd by the Help of two Cranks, put upon the Axis of each Water-Wheel; which, by the Help of 2500 Pieces of Timber, mov'd vertically, gives a Stroke of four Foot, at the Distance mention'd, to the Pumps: At each End of those Pieces of Timber, that move vertically, there passeth a Barr of Iron of five Inches broad, and $\frac{3}{4}$ of an Inch thick; and there passeth two of those Bars of Iron, from every Water-Wheel, to the distance of half a Mile.

So vast, and manifold are the Appendices of this stupendious Machine, superadded to the abovesaid Impediments; and so much Pains is taken, to acquit its Charge at three Lifts, by the Help of so many Water-Wheels, and of so large a Size; as to tugg and push, each a Pair of those massive Bars of Iron, tack'd to a vast Number of Timber-Loggs, backward and forward, for half a Mile in Length, at every Revolution, with a Quickness proportionate, 'tis scarce credible.

But withal, to fetch up three Sets of Pumps, and stamp 'em down again with the same quickness, four Foot at every Stroke; and these to rowse up respectively their lazy streams, with the like Vivacity, from a profound Rest; the Energy of their Projectile Impulse being lost, before they make their Return; this seems to exceed all Human Comprehension, how it can be finally perform'd.

Now, whereas the Author of the said Description, after full View of the said Machine itself, and how it operated according to every Part;

Description of an Engine,

Part; told me, that 'twas writ to let me see that the " Force was all misapply'd; and to " know my Opinion, Whether an Engine of " this Progressive Sort might be propos'd, to " raise Water to the said Height, at one Lift; " and if it cou'd be done at once, without the " Loss of too much Water, by the Pressure of " that Height; he did believe one Water- " Wheel would raise more than all their " fourteen; the Charge of Repairs being im- " mense.

To remove the sole Occasion of his Doubt, being the Loss of too much Water :

First, An Engine of this Sort, being not restrain'd to any Size of Bore, as others be, may hold Water enough; and the more, with the least Loss in Proportion, from the Pressure at whatever Height, as aforesaid: Besides, the Box, which includes the Engine itself, so shuts up the Channel from without, that no Water can issue forth that Way; and the Ladles fit it so exactly within, that as little can fall back into the Tube underneath.

Moreover, the said Box, which contains the Engine, and sustains the Pressure of the Water, and the Forcers, which drive it to its greatest Height; as also the Tubes which convey it thither, are all at once much alleviated of their Burthen; the Stream still tending Upward with a constant and equal Course; whilst that at *Marley*, falling into Dead-Water after every Stroke, the Jerks they suffer are insupportable.

to fetch Water out of the Deep.

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Now, forasmuch as the sole Motive, the
observer of that vast Machine had, to let me
see that the Force was all misapply'd, was to
show my Opinion, whether an Engine of our
progressive Sort might be propos'd, to raise
Water to that Height, at one Lift; it remains
to gratify his Enquiry, with



C H A P.



C H A P. III.

A Brief Account, how the Misapplication of the Force, in other Water-Engines, is rectified to the best Advantage in this Progressive one, here advanc'd.

SINCE *Water-Engines* of all Sorts, whether they be wrought by Suction or Trusion, make use of Pumps of their respective Kinds, and apply their Force in performing their Office, after as different Manner: To begin with those that are the most plain and simple, and proceed to the rest.

First, The Churn Pump has this Advantage above its Fellows, to suck up its whole Portion of Water, one Part of its Drought, and lift up the other at once, by the same perpendicular Stroke; yet, notwithstanding, spends half its Time, and no less of its Current, while it stoops to fetch up a fresh Supply, to renew its Stream: A double Misfortune incident to all other Pumps, and the *Engines* that make use of 'em; as all necessarily do, this Progressive excepted; For,

To take off this Impediment, of fetching such Supplies by Way of Prevention, the Pressure of the Atmosphere upon the Surface of the Fountain, &c. underneath, raiseth a pressure

tiful Stream up the lower Tube, into the Channel of the *Engine*, on its own accord ; where the Forcers constantly receive it, and hoist it up progressively, into the higher ; which conveys it forward to the Place design'd, with a continued Stream, from the Bottom to the Top of its Course, where it is finally disposed of to the Use intended.

Secondly, As to Trusive-Pumps, which are employ'd to force Water to higher Situations ; in regard they depress its Surface, which is rais'd again by Result ; the Stroke is so adverse to the intended Rise of the Stream, that the Substance of it is lost, and only the Shadow remains : And, forasmuch as the Stream is drawn into the Cylinder of the Pump, on the one Side, and squeez'd out on the other, horizontally ; the Stroke being perpendicular, and transverse to the Performance, must needs retard and weaken it in a great measure : And if Weight be added to the Forcer, to hasten and sharpen its Fall ; this only aggravates the Impediment, to fetch it up again.

Whereas it is remarkable, that, altho' the circular Motion of the Forcers deflects the rising Stream from its former Direction, at its Entrance out of the lower Tube into the Channel ; yet withal it keeps the Flux thereof to a constant rate, without any Abatement, the Channel being a quarter of the Circumference of a Circle : And by turning about their common Axis, they pursue its Flux close, according to the same Direction ; and at last restore it again to its Upright Course, with all the Ease and Expedition imaginable.

Thirdly, Pumps of both Sorts, whether they work by Suction or Trusion, suffer the Flux of their Streams to intermit, and their Currents to resettlement into dead Water ; not to be reviv'd without as strong a Stroke, as animated 'em before ; nor to recover their former Speed, but in an equal Space of Time, nor ever to the same Degree, the augmenting Water still growing more ponderous, than to be toss'd up and down between Stroke and Stroke ; and so becomes fix'd at last, by its Adhesion to a longer Space of Tube ; that, after all, either the Power of the first Mover is at a stand ; or the Resistance of all the said Impediments being too obstinate to be enforc'd ; the Tubes, by the impetuous Jerks of their Rencounter, are broken in Pieces.

Whereas to prevent, at once, all the ill Consequences of this intermitting Distemper, the Progressive Forcers still keep their Currents alive, and to an equal Speed, let their Streams grow never so ponderous : If the Force of the Movers be heighten'd proportionably to the Weight of 'em ; and if the Tubes be wide enough, the Adhesion to 'em, while the Motion is constant, and of the same Tendence (let the Height be encreas'd never so much) will do little Harm.

Fourthly, To ease the said Intermitting Distemper, but not perfect the Cure ; when the main Stream is divided into small Rills, and these are driven successively in one common Channel, the Flux of the Current becomes Progressive ; yet those Rills retaining each, for half its Time, their respective Intervals till their Conjunction ; and all coming in play at every

every Revolution, they become jointly as constant, and as lasting an Impediment to their common Stream, as before ; and exerting their Performances but one at once, they weaken and retard it to that Degree, as to reach no considerable Height, tho' never so much enforced by the Power of the first Mover.

A Truth, which the ingenious Mr. *Sorocold* was so sensible of, as to its first Part, that, when the small Bore of his Trusive-Pumps, oblig'd him to make use of no fewer than sixteen, to supply with Water so considerable a Part of *London*, he took care to reduce 'em to a four-fold Stream; and to re-unite these in one, to render the whole progressive, without Intermission : And that the Water might rowl with more freedom within itself, up a Tube of the largest Capacity: This, I say, gave Ease to the aforesaid intermitting Distemper; and sufficiently accommodated his *Engine* to a *London* Situation, that required not above twenty or thirty Yards of Height, to furnish it : But to have perfected the Cure to a hundred Yards higher, he must have re-united all his sixteen Streams into one, and his Pumps accordingly, for the same Reason : For

Finally, It was found more feasible at *Marley*, to raise Water by Protrusion, 450 Foot (or thrice fifty Yards) at three Lifts, with so many Ranks of Pumps, and by the Help of twenty eight Barrs of Iron, and 2500 Pieces of Timber; than to encounter a Complication of all the aforesaid Impediments, at a greater Height than fifty Yards at a Lift : For, altho' each of 'em apart, had necessarily either diminish'd the Quantity of the

Stream, or cut short the Height whereto it ought to be rais'd; yet more Force wou'd, in some measure, have surmounted the Difficulty; but all being combin'd to enforce one another, wou'd have render'd the Operation impracticable, in every Respect, by any Mechanical Power whatsoever.

How much more expedient had it therefore been, for saving of Time, Labour, and Charges; to have waved all Thought of so awkward intermitting Pumps, as pester'd that Work, with such useless Lumber of Iron, and Timber, that attended 'em; and instead of 'em to have re-assumed a Tube, capable of holding their whole Stock of Water; and a Water-wheel of Force, to raise it to that stated Height at one Lift; by the Assistance of a suitable *Progressive Engine*; which, being rid of all the above-mention'd Impediments, wou'd have had nothing left, beside Weight of Water, to have supported, and struggl'd with.

This being suppos'd, the Quantity of the Water, and the Height of its Advance, wou'd have held this Proportion to the Force apply'd; that, if one Horse cou'd raise ten Ton *per* Hour twenty-five Yards (which is practicable,) two Horses wou'd raise the same fifty Yards; four Horses, a hundred Yards; and six Horses, a hundred and fifty Yards; which is the stated Height at *Marley*: And this Computation, being transver'd; to what Height one Horse wou'd advance ten Ton an Hour, two Horses wou'd lift twenty Ton; three Horses, thirty Ton; and so progressively: So that the six Horses, which rais'd ten Ton

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Ton per Hour, at *Marley*, doubl'd, wou'd furnish twenty Ton per Hour; eighteen Horses, thirty Ton per Hour; and twenty-four Horses, forty Ton to the said Height: And, if the Force of twenty-four Horses, be equivalent to that of one Water-wheel of thirty Foot Diameter; it wou'd raise as much Water, as fourteen do at present: But the Quantity actually rais'd there, and this Equivalence being unknown, we are still left in the Dark: But if it be true (which is credibly reported) that the whole Stream is convey'd from *Marley*, to *Versailles*, by a Tube of only eight Inches Bore; we may rest well assur'd, that an Engine of four Foot Square, and one Foot thick, wou'd suffice to raise the same from the River *Seine*, at the Bottom of the Hill, up to the Top of it; the Force, that at present is employ'd to do the Jobb, is so wholly misapply'd.

Finally, Forasmuch as the first Chapter of this Treatise, hath display'd the distinguishing Perfections, and Advantages of this Progressive Sort of *Water-Engines*, above all others, viz. The unparallell'd Plainness and compactness of its Structure, the Ease and efficacy of its Operation; the large and boundless Extent of its Performance, and unmodious Application to all Manner of Uses: And the two following Chapters, have disentangled and freed it from all those Defects, and Incumbrances, incident to all the said Sorts, to their great Disadvantage, and prejudice in all those Respects:

spects: It remains to conclude, That it is the absolute Master-piece of the whole Art, and so compleatly perfect in every respect, as to be capable of doing our Nation better Service, both by Sea and Land, than all the rest.

E I N I S.

